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THE ECOLOGY OF SHARP-TAILED GROUSE DURING WINTER IN SASKATCHEWAN

by

© Adam P. Schmidt

A Thesis

Submitted to the Faculty of Graduate Studies and Research

in Partial Fulfillment of the Requirements for the Degree

of Master of Science

Department of Zoology

Edmonton, Alberta

Fall, 1980

The University of Alberta

Faculty of Graduate Studies and Research

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled, "The ecology of sharp-tailed grouse during winter in Saskatchewan" submitted by Adam P. Schmidt in partial fulfillment of the requirements for the degree of Master of Science.

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Supervisor

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Date April 25, 1980

ABSTRACT

The ecology of sharp-tailed grouse *(Pedioecetes phasianellus)* in winter was investigated at Duperow, Saskatchewan in 1976-77 and 1977-78.

During autumn grouse were observed most frequently in cultivated fields (57%) and in aspen bluffs (16%). Use of cultivated fields (35%) decreased between autumn and winter while at the same time use of gravel roads (26%) and tall shrubs (22%) increased. In spring grassland (28%), cultivated fields (26%), aspen bluffs (19%) and tall shrubs (18%) received the greatest use by grouse.

Between September and March the diet of sharp-tailed grouse consisted primarily of grains (wheat *(Triticum aestivum)*, oats *(Avena sativa)*, barley *(Hordeum vulgare)*) and berries (silverberry *(Elaeagnus commutata)*, snowberry *(Symphoricarpos occidentalis)*, rose *(Rosa* sp.*)*, juniper *(Juniperus horizontalis)*). Dominant foods in April and May were aspen catkins *(Populus tremuloides)* and dandelion leaves and flowers *(Taraxacum officinale)*.

Crude protein of major foods was 5-7% for berries, 11-14% for buds and 15% for catkins. Changes in food habits through the seasons may be related to nutritional value of the major foods.

Grouse roosted under snow in tall shrub habitat where vegetation was sparse (less than 3.1 stems/m^2) and where snow was at least 19 cm deep without a significant crust.

Dominant vegetation was silverberry. Changes in snow depth and quality in the major habitat types through the winter were documented. These changes affected availability of food and suitability of sites for roosting.

One hundred and seventy grouse were collected and necropsied. Significant changes in total body weights, pectoral muscle weights and leg muscle weights occurred from autumn to spring. Protein and fat reserves which had increased in autumn decreased in mid-winter indicating the grouse were in a negative energy balance at that time. Protein and fat reserves increased again in the spring. Increases in leg muscle weights and the width of the tail of males between February and April were related to reproductive condition.

Although grouse were in a negative energy balance during part of the winter the mean body weights in February did not drop significantly lower than mean weights in October.

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I would like to thank my supervisor Dr. Vic Lewin for his advice and encouragement throughout this study, for his critical comments on this thesis and for his patience in waiting for it to be completed. Members of my committee, Dr. F. C. Zwickel, Dr. D. A. Boag and Dr. A. R. Robblee helped with criticism and discussion of the work. Dr. F. C. Zwickel also reviewed an earlier draft of the thesis.

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This study could not have been conducted without the friendly co-operation of the residents in the Duperow area who gave me access to their lands.

Special thanks go to my wife, Louise, who assisted with the analysis of the crop and gizzard contents and who put up with many inconveniences during the study.

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INTRODUCTION

Many species of birds living in northern latitudes in summer avoid the snow and cold of winter by migrating to areas where temperatures are warmer and food is more abundant. Species which do not migrate obviously must have adapted to winter conditions. Formozov (1973) states that species of birds such as willow ptarmigan *(Lagopus lagopus)* and mammals such as varying hare *(Lepus americanus)* have characteristic adaptations such as white coloration and special foot adaptations which undoubtedly were influenced by snow cover taking part in selection. Their ranges roughly correspond to regions of hard and continuous winters with abundant snowfall. These species have been called "chionophiles" or "snowlovers" by Formozov (1973) who suggests they have adapted to winters with snow to such an extent that the absence of snow or factors affecting snow abundance and quality can have a significant effect on survival in winter.

Gullion (1970) suggests that in northern Minnesota the survival of ruffed grouse *(Bonasa umbellus)* during winter depends largely on snow conditions. He believes that grouse which roost under snow conserve energy and are protected from predation. He concludes that snow conditions which prevent them from roosting in snow result in a decline in the population. However, the evidence used to arrive at this conclusion was largely correlative.

Species such as sharp-tailed grouse *(Pediocetes phasianellus)* and spruce grouse *(Canachites canadensis)* also are found in regions which experience cold temperatures and snow in winter. The ways in which these and other species of gallinaceous birds have adapted to a harsh winter environment and the magnitude of the effect of cold temperatures and snow conditions on their survival have received limited attention.

If body weight is used as a general index of condition then some species are in better condition during the winter than in summer. Total body weights of sharp-tailed grouse (Hillman and Jackson 1973), spruce grouse (Pendergast and Boag 1973) and ruffed grouse (Thomas et al. 1975) are greater in winter than in summer. Willow ptarmigan reach highest body weights in fall and spring (West and Meng 1968). This species is migratory and peak weights appear to be correlated with time of migration.

Although most species increase in weight during the winter the increase is not due to an increase in fat deposition. Caldwell (1976) did not find any differences in the fat content of sharp-tailed grouse collected during different periods of the year. Similarly Pendergast and Boag (1973) reported that fat deposition was not a significant factor in weight changes of spruce grouse. Thomas et al. (1975) found that the fat content of ruffed grouse carcasses was low with no marked seasonal changes and concluded that lipids were not of great metabolic importance

particularly during the winter months. These studies suggest that grouse have not developed the adaptation of depositing large amounts of fat to insulate against heat loss and to mobilize as emergency energy reserves during times of high energy demands. Experiments by Evans and Dietz (1974) on sharp-tailed grouse nutrition in winter and by Evans and Moen (1975) on heat loss of sharp-tailed grouse in simulated winter environments suggest that energy deficits can occur. If energy deficits do occur in the wild what is the effect on individuals and what is the ultimate effect on the population?

Formozov (1973) suggests that severe winters with above average snowfall have decimated gray partridge *(Perdix perdix)* and pheasants *(Phasianus colchicus)* in Russia and Europe. He believes the declines were due to starvation since deep snows covered their food. Formozov (1973) also suggests that a lack of snow or snow with an icy crust may also be detrimental to survival of gallinaceous birds. In years of low snowfall in combination with low temperatures species such as black grouse *(Lyrurus tetrix)* and hazel grouse *(Tetrastes bonasia)* have declined. The reason suggested for the decline was that they perished because they were unable to roost under snow to insulate themselves from cold and wind (Formozov 1973).

Indirect evidence (unpublished data, Saskatchewan Department of Tourism and Renewable Resources) suggests that mortality of sharp-tailed grouse over the winter can be

substantial. Sharp-tailed grouse populations are monitored throughout the province by conducting surveys of territorial males on dancing grounds. Between 1970 and 1973 the densities of males varied from 1.3 to 1.7 males/km^2 (3.3 to 4.4 males/mi^2). In 1974 the density dropped 40% to 1.0 males/km^2 (2.6 males/mi^2). Densities on some individual survey blocks dropped as much as 66%. One block dropped from 3.3 males/km^2 (8.6 males/mi^2) in 1973 to 1.1 males/km^2 (2.89 males/mi^2) in 1974. While decreases in densities had been recorded on individual blocks in the past an overall decrease of this magnitude over such a large area had not been recorded. The decline in the population was correlated to an unusually long winter with above average snowfall.

Weather and snow conditions may have an indirect effect on a population in addition to the direct loss of individuals. Experiments with penned hen pheasants (Gates and Woehler 1968) showed that below-normal body weights in late winter were associated with delayed attainment of maximum spring weights, later egg laying and lower body weights throughout the laying period. There were no adverse effects on egg hatchability or chick survival but the number of eggs laid was reduced. If adverse weather and snow conditions result in wild female gallinaceous birds coming through the winter weighing less than normal it is possible that a sequence of events similar to the experimental results could occur. The ultimate effect would be that fewer chicks would be produced and the peak of the hatch would be

later in the season. If these chicks have a lower survival rate than chicks produced earlier the effect on the population could be significant. Gullion (1970) believes that periodic fluctuations in ruffed grouse populations are not so much the result of a "die-off" or accelerated losses among living grouse as they are the failure to recruit enough young birds each season to replace those lost through "normal" attrition.

I attempted to study how sharp-tailed grouse have adapted to their environment by following changes in body condition, food habits and behavior through the winter and relating these changes to environmental conditions such as temperature and snow depths. Such baseline data are needed before predictions can be made on the effect of winter on sharp-tailed grouse populations.

Field work was conducted from October 1976 to May 1977 and from September 1977 to May 1978.

THE STUDY AREA

Location

The study area was located in west-central Saskatchewan between the hamlet of Duperow and the town of Biggar, in an area referred to locally as the "Argo Bush" (Figure 1). The entire study area covered approximately 180 km^2 (70 mi^2). Most of the field work was conducted immediately east and south of Duperow and included a sharp-tailed grouse survey block (44 km^2) monitored annually by the Saskatchewan Department of Tourism and Renewable Resources (Figure 2).

Soils and Topography

This area is located in the dark brown soil zone. Soils on the core of the study area are sand and sandy loam, while those on the perimeter are fine sandy loam. Soils in adjacent areas are loam, clay loam or silty loam. Stabilized sand dunes occur in the central portion of the intensive study area.

Topography in the central dune area is quite broken; over most of the remainder of the area it is level to gently rolling.

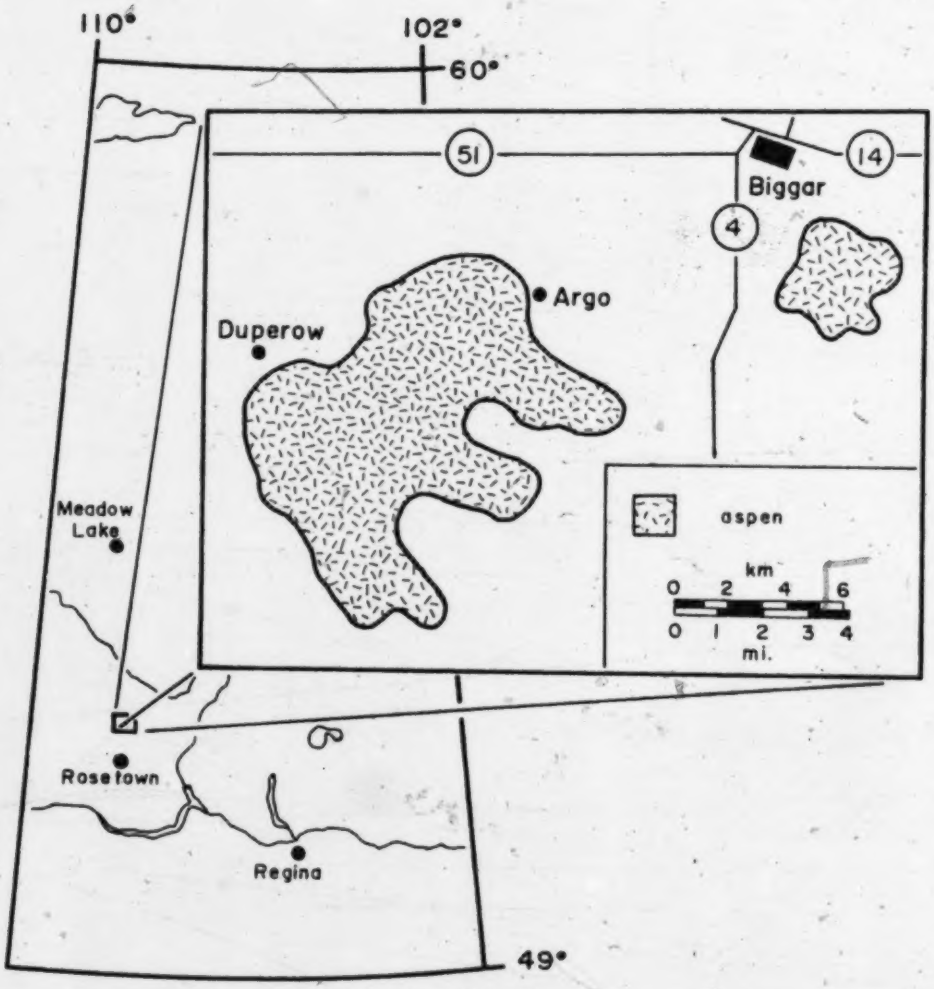

Figure 1. Location of the study area in Saskatchewan.

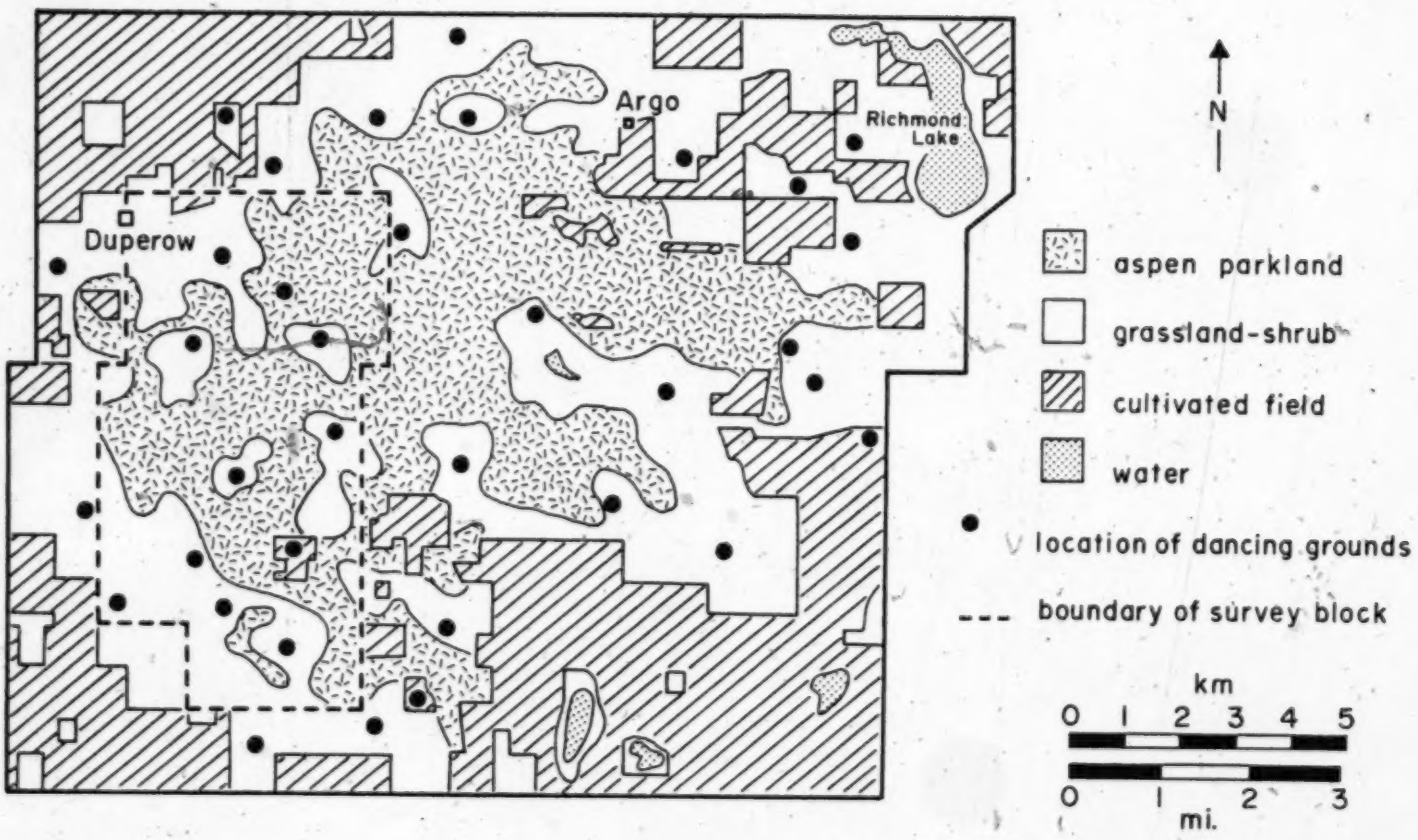

Figure 2. Distribution of major habitat types, location of the Duperow survey block and locations of sharp-tailed grouse dancing grounds on the study area, 1977.

Climate

The climate in this area is described as continental semi-arid which is characterized by warm summers, cold winters and moderately low annual precipitation. Temperatures range from a mean of 18° C (64° F) in July to a mean of -16° C (3.5° F) in January. Annual precipitation ranges from 30.5 cm to 35.6 cm (12 to 14 inches) of which 75% falls from May to September. Annual snowfall ranges from 76.2 to 88.9 cm (30 to 35 inches).

Land Ownership

Seventy-five percent of the intensive study area is privately owned. The remainder is owned by the Government of Saskatchewan and is leased to farmers for grazing.

Limits to Agriculture

The soils on the study area have been classed as having severe limitations for agricultural production. Their capability is restricted to producing perennial forage crops, although improvement practices are feasible in some areas (Canada Land Inventory 1976). Cultivated fields are subject to wind erosion.

Vegetation and Land Use

Aspen *(Populus tremuloides)* is the dominant vegetation on the study area (Figure 2). The central portion is heavily treed; scattered small clones occur around the perimeter. A central dune area is dominated by aspen on the slopes and willow *(Salix* spp.), balsam poplar *(Populus balsamifera)* and small patches or isolated individuals of river birch *(Betula occidentalis)* in low areas between dunes and on other mesic sites. Ridges and many south-facing slopes are dominated by shrubs and grasses including silverberry *(Elaeagnus commutata)*, choke cherry *(Prunus virginiana)*, rose *(Rosa* sp.), juniper *(Juniperus horizontalis)* and spear grass *(Stipa* sp.). On more level ground the shrubs listed above as well as snowberry *(Symphoricarpos occidentalis)*, are found in isolated patches, in combination with each other or around the perimeters of aspen bluffs. Silverberry is the dominant shrub over the entire study area.

Nearly all of the land is used for grazing cattle. Most of the cultivated land is located in the southeast corner of the study area. Dominant cereal grains are barley *(Hordeum vulgare)*, oats *(Avena sativa)*, rye *(Secale cereale)* and wheat *(Triticum aestivum)*. Active farmyards occur but all of them are located on the periphery of the dune area. The center of the block contains several farmsteads that have not been occupied for many years. Fields which were formerly cultivated are seeded back to grass. Many of them

have been colonized by native grasses and shrubs and are recognizable as old fields only on aerial photographs.

METHODS

Breeding Population Survey

Part of the study area (43.5 km^2, Figure 2) is a survey block of the Saskatchewan Department of Tourism and Renewable Resources to monitor sharp-tailed grouse populations. Male breeding populations were determined by counting all males on dancing grounds (arenas) between April 11th and May 8th from 1976 through 1979. Starting at or shortly before sunrise known dancing grounds were checked, all roads and trails were driven and stops were made at frequent intervals (usually 0.8 km) to listen for vocalizations from displaying grouse. When a dancing ground was located an attempt was made to approach as close as possible without flushing the birds. The total numbers of males and females were recorded. Since shrubs sometimes concealed birds it was often necessary to flush the birds off the dancing ground to determine the total number. Females did not return but males usually returned within 5-10 minutes and resumed displaying. The number of the males which returned and actively displayed was the figure which was used for calculating the density of the breeding males on the study block. This count was considered to be the most accurate since it included only the territorial males. Each dancing ground was visited at least twice (3 times in 1977 and 1978). Density of breeding males was calculated by summing the high counts on each dancing ground and

dividing by the area of the block.

Monitoring Snow Depths

Snow depths were monitored after each major snowfall at stations established in major vegetation types (grain stubble, low shrub, tall shrub, willow and aspen). At each station 10 measurements, spaced at approximately 1 m intervals, were taken along a transect which was established after the first snowfall. The average of the measurements was recorded as the average snow depth. Characteristics of the snow were described in qualitative terms with particular attention being paid to the thickness and depth of icy crusts. Broad categories used to describe snow conditions were: pure ice, icy crust (from melting) or wind-packed crust (could be broken by squeezing between thumb and fore-finger), ice crystals (found in those layers closest to the ground, blue to grey in color, pours easily like large sand grains, is not compacted) and new snow (very white, light and fluffy).

Grouse Roosting in Snow

During winter, when snow conditions are suitable, sharp-tailed grouse tunnel into snowdrifts where they spend the night and portions of the day. In these "snow-roosts"

they are protected from wind and temperatures here are warmer than on the surface because the insulating properties of snow allow body heat to warm this enclosed space. There are substantial energy savings to grouse which are able to roost in snow during the coldest part of the year. Therefore, snow conditions and depth which affect the ability of grouse to roost can have implications for their survival.

When grouse were flushed from roosts in the snow or if recently used roosts were observed during other field activities the following measurements were recorded: snow depth, roost depth (distance from surface of the snow to the floor of the roost), thickness of the roof of the roost, length of the roost and distance to the nearest shrub (Figure 3). The snow condition was described in qualitative terms and the thickness of any icy crusts and the depths at which differences in crystal size occurred were recorded. The method of entry and exit was noted as well as the dominant vegetation in the area.

Seasonal and Daily Habitat Use and Behavior of Grouse

Records were kept on habitat use and behavior of all grouse which were observed on the study area. During autumn and spring access was good throughout the study area but during winter access was limited to the main grid roads. As a result the observations in spring and autumn

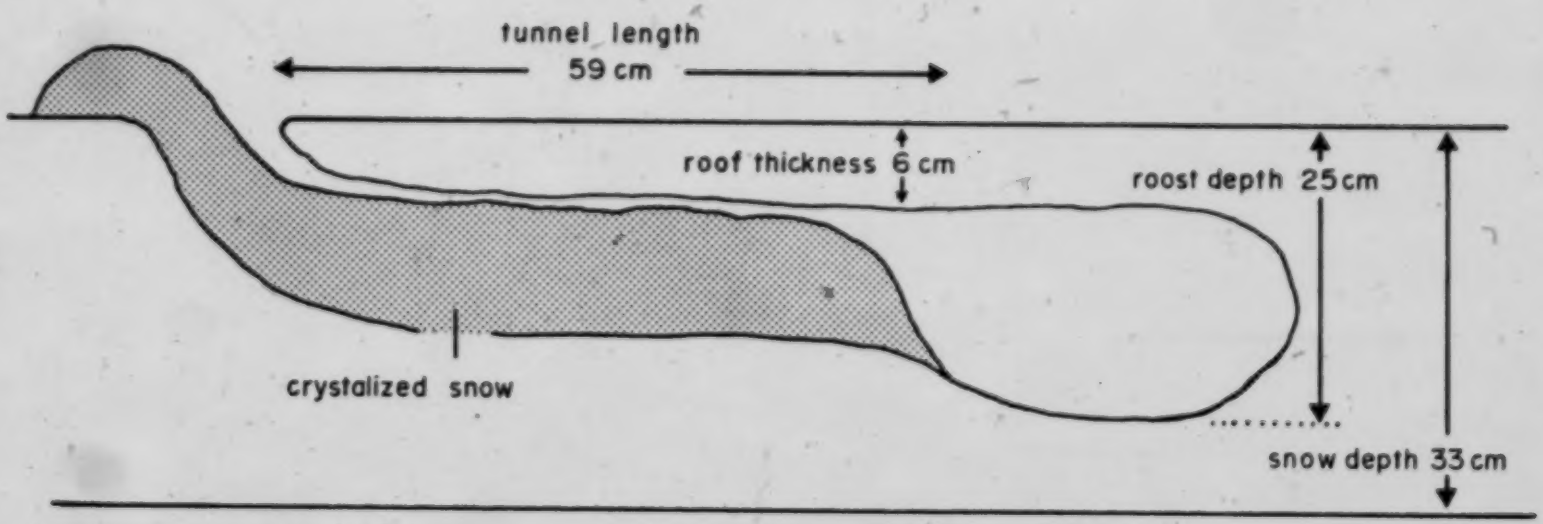

Figure 3. Cross section of a typical snow-roost showing standard measurements recorded. Dimensions listed are means.

covered a much more extensive area than in winter. Areas not accessible by truck were covered by walking or snowmobile. The same routes were covered on a regular basis (some areas every day, others once or twice a week). Since all habitat types were crossed by the routes and because of the high density of grouse on the study area I believe that the observations accurately reflect the habitat use of the grouse at Duperow.

All observations of grouse were recorded on a standard form which included the following information: location, date, time, weather conditions, habitat, dominant vegetation, snow depth and conditions, number of birds and behavior. Habitat categories included grassland, low shrub, tall shrub, trees, gravel road and cultivated fields. Behavior categories included feeding, picking grit, loafing, roosting and unknown. Seasonal observations were grouped into Autumn (September 1 - December 15), Winter (December 15 - March 15) and Spring (March 15 - May 31). Daily observations were grouped into the following categories: dawn to 1100, 1101 to 1400 and 1401 to dark. Habitat use and behavior on a seasonal and daily basis were expressed as a percentage of all birds observed. If birds were observed along the interface of two habitat types half of the individuals were assigned to each type.

Collections and Necropsies of Grouse

Grouse were collected with a shotgun or with a .22 caliber rifle. Most birds (over 80%) were collected with the rifle. The following data were recorded for each collected bird: location, date, time, temperature, wind direction and estimated velocity, cloud cover, size of flock, behavior prior to collection, habitat type and dominant vegetation. During the autumn and spring the birds were stored on ice until necropsied or frozen. In winter, temperatures were usually cold enough that birds left outside started to freeze immediately. Carcasses were weighed and measured before being frozen. During necropsy the information on the form in Appendix 1 was recorded.

Sex was determined by the color pattern of the crown and central tail feathers (Henderson et al. 1967) and by examination of the gonads. Age was determined by wear and replacement of primaries (Taber 1969), by the presence (juvenile) or absence (adult) of a bursa of Fabricius or by measuring the diameter of the proximal primary (Wishart et al. 1976).

Fat depots on the sides of the neck (Figure 4) can be observed externally through the cervical apterylae. The extent of this depot was mapped and compared later to the amount of fat removed. A total of three fat depots were removed and weighed. The first was the interclavicular depot which is located along the sides of the neck and extends

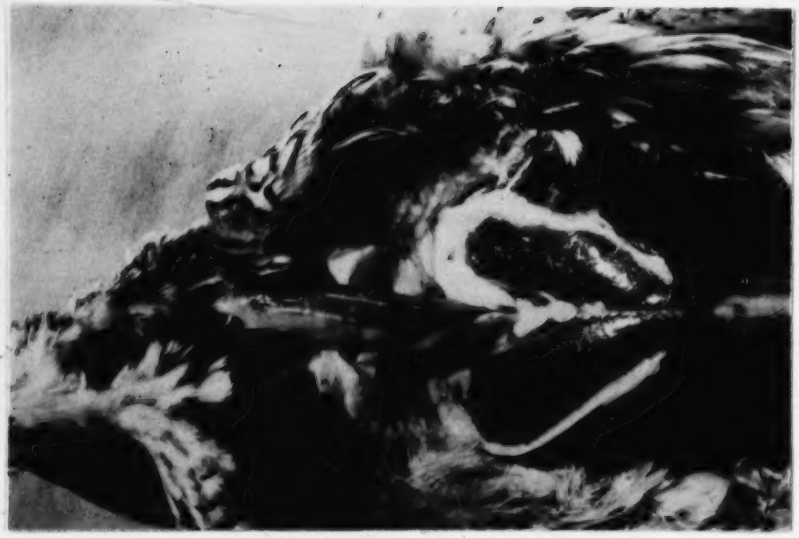

Figure 4. The interclavicular fat depot on a sharp-tailed grouse as viewed externally through the left cervical apterium (upper photo) and internally after dissection (lower photo). Weight of fat in this depot was 10.3 grams. Weights of fat extracted from this depot in other specimens ranged from 0 to 28 grams.

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downward from the base of the neck around the sides of the crop (Figure 4). Also included in this depot was fat from behind the crop at the lower base of the neck. The second depot was located along the posterior edge of the sternum (Figure 5). The third was the abdominal or omental fat which surrounds the gizzard and extends in a thin layer posteriorally between the abdominal muscles and the intestines. In some cases it surrounds the bursa and cloaca. Mesenteric fat was not included. The abdominal depot corresponds to fat deposits identified by Woodall (1978) as omental fat in redbilled teal *(Anas erthrorhyncha)* and abdominal fat described by Kubena et al. (1974) in domestic chickens *(Gallus domesticus)*.

Crop and gizzard contents were removed, weighed and frozen for later analysis. The eyes, crop, gizzard, caeca , and small and large intestines were examined for parasites that were preserved for later identification.

Crop and Gizzard Content Analysis

Crop contents were segregated, identified and volumes of food items were determined by displacement with water. The contents were then dryed in an oven at 70° C for 24 hours and their dry weights recorded. Data from crops were pooled for each month and the volume of each food item was expressed as a percentage of the total volume occupied by all items.

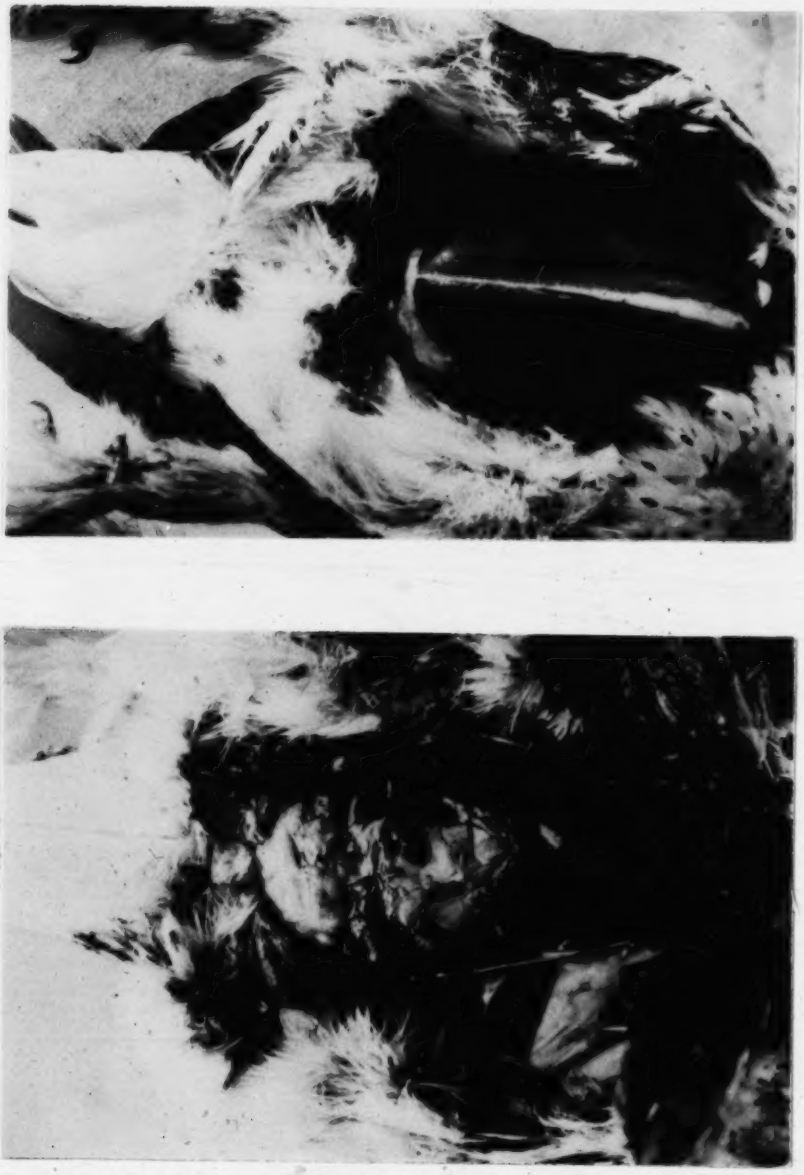

Figure 5. Fat depots located along the posterior edge of the sternum (upper photo) (0.6 grams) and in the abdominal cavity (lower photo) (5.5 grams) of sharp-tailed grouse. Weights of fat extracted from the depot at the rear of the sternum ranged from 0 to 2 grams in other specimens. Weights of fat extracted from the abdominal depot ranged from 0 to 30 grams.

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The percentage of the total dry weight was also calculated for each species. Gizzard contents were segregated and identified but were not measured quantitatively. These data were combined with those from the crops to calculate frequency of occurrence of food items.

Determination of Food Habits and Preferences From Tracking Grouse in Snow

Fresh tracks of grouse in snow were followed to determine food habits and preferences. Sites chosen for this purpose were those where grouse previously had been observed feeding or where there was evidence of feeding after the tracks had been followed at least 50 meters. The area sampled was a linear plot along the tracks and extending 12.5 cm on each side. At 25 cm intervals the following information was recorded:

1. Plant species present.
2. Plant species which had buds or berries available for browse within the rectangle and within 30 cm above that area.
3. Plant species within that area that had been browsed.

The system for recording this information was simple. Each species was designated a letter or combination of letters. A lower case letter was used to indicate presence

of a species without buds or berries available to the grouse. A capitalized letter indicated that the species had buds and berries available but there was no evidence of browsing and a capital letter which was circled indicated that the species had been browsed. Thus the symbols sv R (Ch) indicated a segment of the trail where silverberry, rose and chokecherry were present. No buds or berries were available on the silverberry stems. Some rose hips were available but were not browsed. Chokecherry buds were available and some were browsed. The number of stems present or the number of buds or berries browsed were not recorded. Stems were not counted because vegetation at feeding sites was fairly sparse and usually only 1 or 2 stems of 1 or 2 species were present on each trail segment. If several stems of one species were observed on a plot they were often branches of the same plant which was partially buried by the snow. Also a general index of density is given by the number of segments of a given trail on which no vegetation was recorded. The number of browsed and unbrowsed buds and berries were not counted as the main purpose of tracking was to determine whether grouse were selecting some species over others.

The size of the plot was chosen as it relates to dimensions of this species. The total length of a grouse from the tip of the beak to the tip of the tail is between 33 and 36 cm. When the bird is standing its length is approximately 25 cm. Since the tracks indicated that grouse tended to walk directly to plants which they browse rather

than stretching their neck laterally, I decided that the width of the plot should also be 25 cm. It seems logical that a stationary grouse could browse anything within a 25 cm square but once it had browsed everything within that area it would have to move on to the next "plot". The height of 30 cm was chosen because the tracks indicated that although some grouse jumped in the air to get at berries out of their reach, the maximum height at which they successfully obtained berries was 30 cm. Snow depth and condition were also recorded at 10 m intervals.

Aldous (1943) used a similar technique to record food habits of sharp-tailed grouse. He followed tracks and recorded species of plants utilized by grouse at approximately one foot (30 cm) intervals.

Protein Content of Food Items

Major food items were collected from 8 to 12 locations on the study area. Frozen buds and berries were collected from November to March. Catkins were sampled in late April shortly after they emerged but before they fell from the trees. Samples were frozen and stored in plastic bags. Collections from each species were as random as possible. Material was collected from at least 5 plants at each site and from several branches on each plant. Efforts were made to collect material from portions of the plant normally browsed by grouse not just those parts readily accessible to the

collector. Samples from two to four sites were pooled to reduce the cost of analysis. The material was weighed, dryed at 70° C in an oven for 24 hours and reweighed to determine moisture content. It was then ground through a 2 mm screen in a Wiley Mill and submitted to the Feed Testing Laboratory, University of Saskatchewan, for analysis of crude protein.

Statistical Analysis

Statistical tests used in analysis of data were taken from Zar (1974) and Li (1965). Groups of means were compared by analysis of variance. Pairs of means were compared using a t-test. Differences were considered significant at the 5% level. If means were different by analysis of variance those which were different were identified with Duncan's Multiple Range Test.

RESULTS

Densities of Breeding Males

The results of the surveys of territorial males on the Duperow survey block from 1976 to 1979 are compared in Table 1. Densities varied from 6.5 to 9.1 males/km^2. In addition to the 15 dancing grounds included in the survey block, 20 were located on the remainder of the study area (Figure 2) and more could probably be located off the block if the area was surveyed intensively. Counts of territorial males on these grounds were not conducted on a regular basis.

Sex and Age Ratios

One hundred and sixty-two grouse were collected on the study area between September 1976 and May 1978. The sex ratio was 116 males: 46 females. Since some males were collected on dancing grounds, this probably biased the sex ratio, but even when these males were eliminated the ratio was still heavy to males; 69 males: 31 females (223 males: 100 females) in 1976-77 and 63 males: 37 females (170 males: 100 females) in 1977-78.

The ratio of adult to juvenile males was 49:35 and for females, 38:8. The combined ratio is 87 adults: 43 juveniles, or 49 juveniles: 100 adults. Because of the small sample size data from both years were combined.

Table 1. Counts of male sharp-tailed grouse on dancing grounds on the Duperow Block, 1976-1979.

Dancing Ground Number	Number of Active Males 1976	1977	1978	1979
1	39	41	42	57
2	17	24	24	40
3	21	21	22	46
4	63	35	28	36
5	37	21	23	32
7	19	13	8	19
8	13	19	14	15
9	22	25	22	26
10	23	18	19	13
11	16	16	15	20
12	-	13	10	16
Subtotal	270	246	227	320
Density	7.5/km^2	6.9/km^2	6.3/km^2	8.9/km^2
16		19	17	20
17		21	11	14
18		22	18	27
19		9	8	13
Total		317	281	394
Density		7.3/km^2	6.5/km^2	9.1/km^2

The block was expanded from 35.8 km to 43.5 km in 1977 to include dancing grounds 16, 17, 18 and 19. Dancing grounds 13, 14 and 15 are off the block. Dancing ground 6 is no longer active.

There were 18 flocks from which at least two grouse were collected. Assuming that these birds were representative of the sex and age composition of the flock, 15 of 18 flocks (83%) contained birds of only one sex. The collected grouse were the same age in 9 of 11 flocks (82%) containing males. Collected grouse were the same age in 3 of 4 flocks (75%) containing females. Of the 3 flocks from which both males and females were collected only the birds from one flock (33%) were the same age.

Males were collected later in the day, on average, than females (Table 2). However, the differences were not statistically significant. From December to February the average flock size from which grouse were collected was 10.04 birds (47 flocks) for males and 4.82 birds (28 flocks) for females.

Table 2. Mean times of collection of male and female sharp-tailed grouse.

	Mean Collection Time		Mean Collection Time	
	n	Males	n	Females
December	14	11:35 AM	6	11:07 AM
January	20	11:16 AM	7	10:49 AM
February	13	10:52 AM	9	10:44 AM

Snow Depth and Condition

The winter of 1977-78 was slightly cooler than 1976-77. Mean temperatures in December, January and February respectively were 7, 17 and 11° C below the means of the previous year. Total accumulated snowfall was 73 cm in 1977-78 compared to 60 cm in 1976-77 (Figure 6). Figure 7 illustrates changes in snow depths on four major habitat types. In 1977-78 snow cover arrived earlier and persisted longer than in 1976-77. Snow depth was greater in 1977-78 than in 1976-77 during comparable time periods. Depth and condition of snow in three habitat types in 1977-78 are compared in Figure 8. A compacted crust in the low shrub type was recorded as early as December 12 compared to January 9 for tall shrub and February 24 for willow. Ice crystals had started to form in the lower layers of the snow in all three habitats by December 12. Crystalization had reached the upper layer of snow in the low shrub type by January 9 but was not observed to be complete in the tall shrub before February 11 and in the willow before March 9. Light fluffy snow without a surface crust was recorded for the longest period of time in the willow habitat type. On grazed grassland the snow became drifted and compacted by wind within a few days after falling. Snow conditions in stubble followed a pattern similar to that recorded for low shrub. Snow conditions in aspen were similar to those found in willow except in areas where the edge of the stand was exposed to wind. In such areas deep snowdrifts were formed.

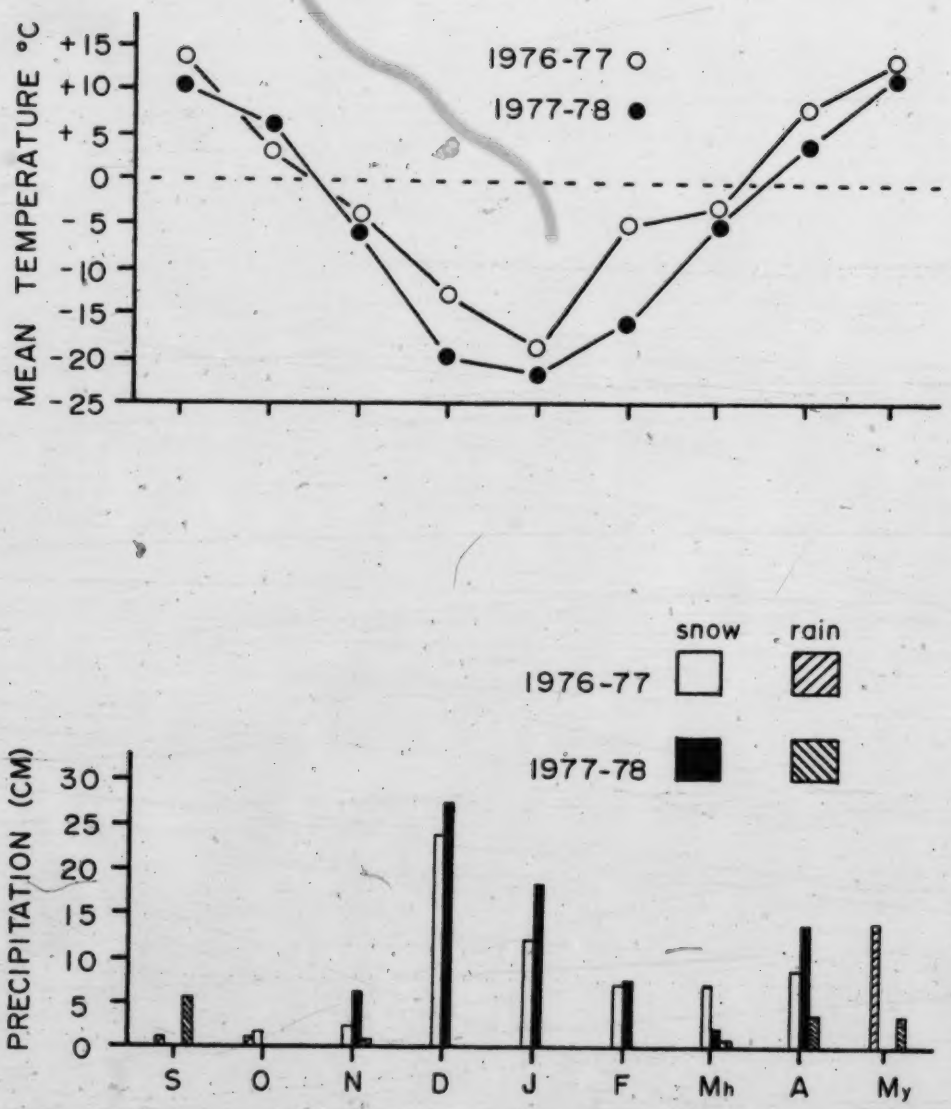


Figure 6. Precipitation and mean monthly temperature at Biggar, Saskatchewan.

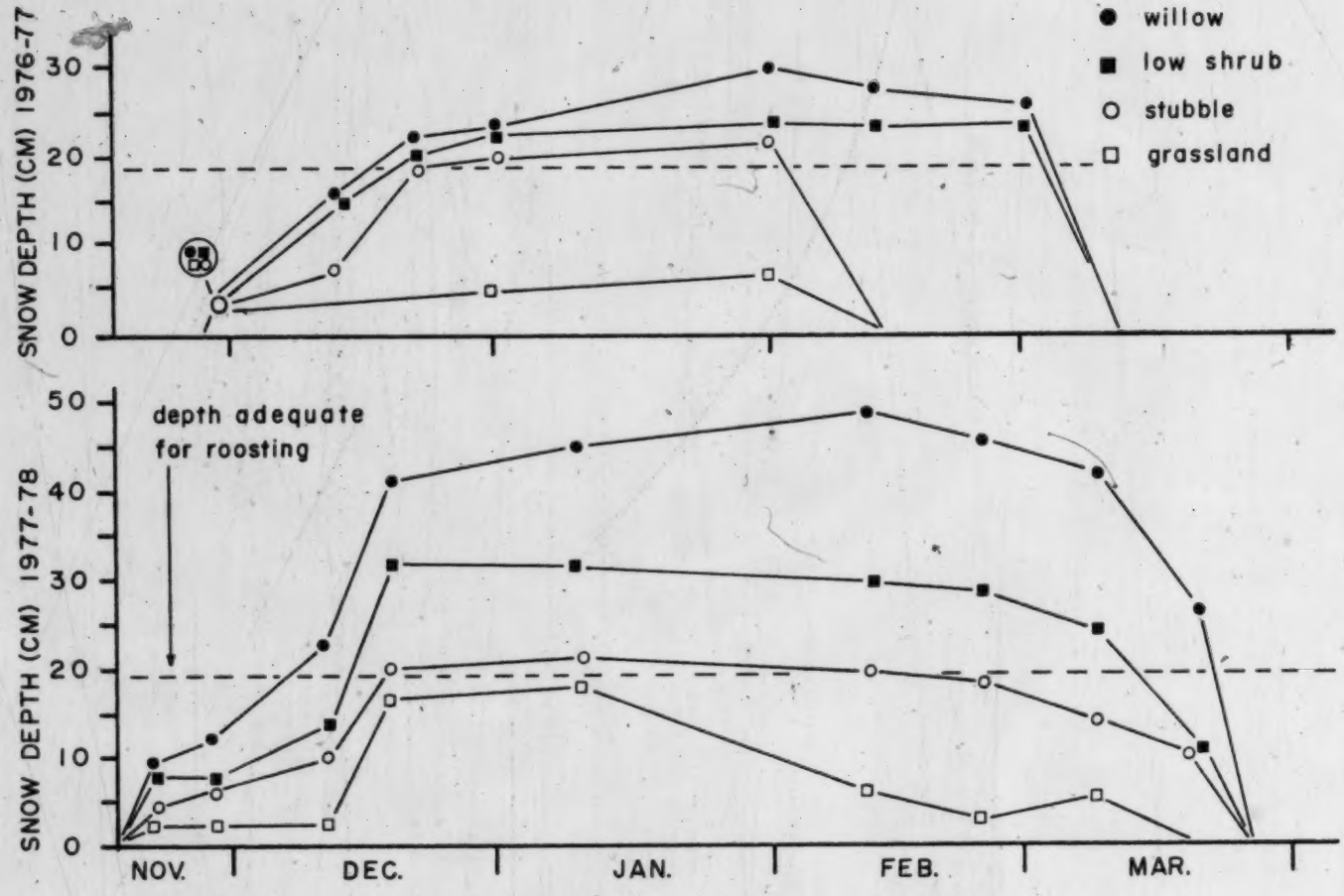


Figure 7. Snow depths in four major habitat types on the Duperow study area. Depths in aspen bluffs and in tall shrub stands dominated by silverberry followed a pattern similar to the tall shrub stand dominated by willow.

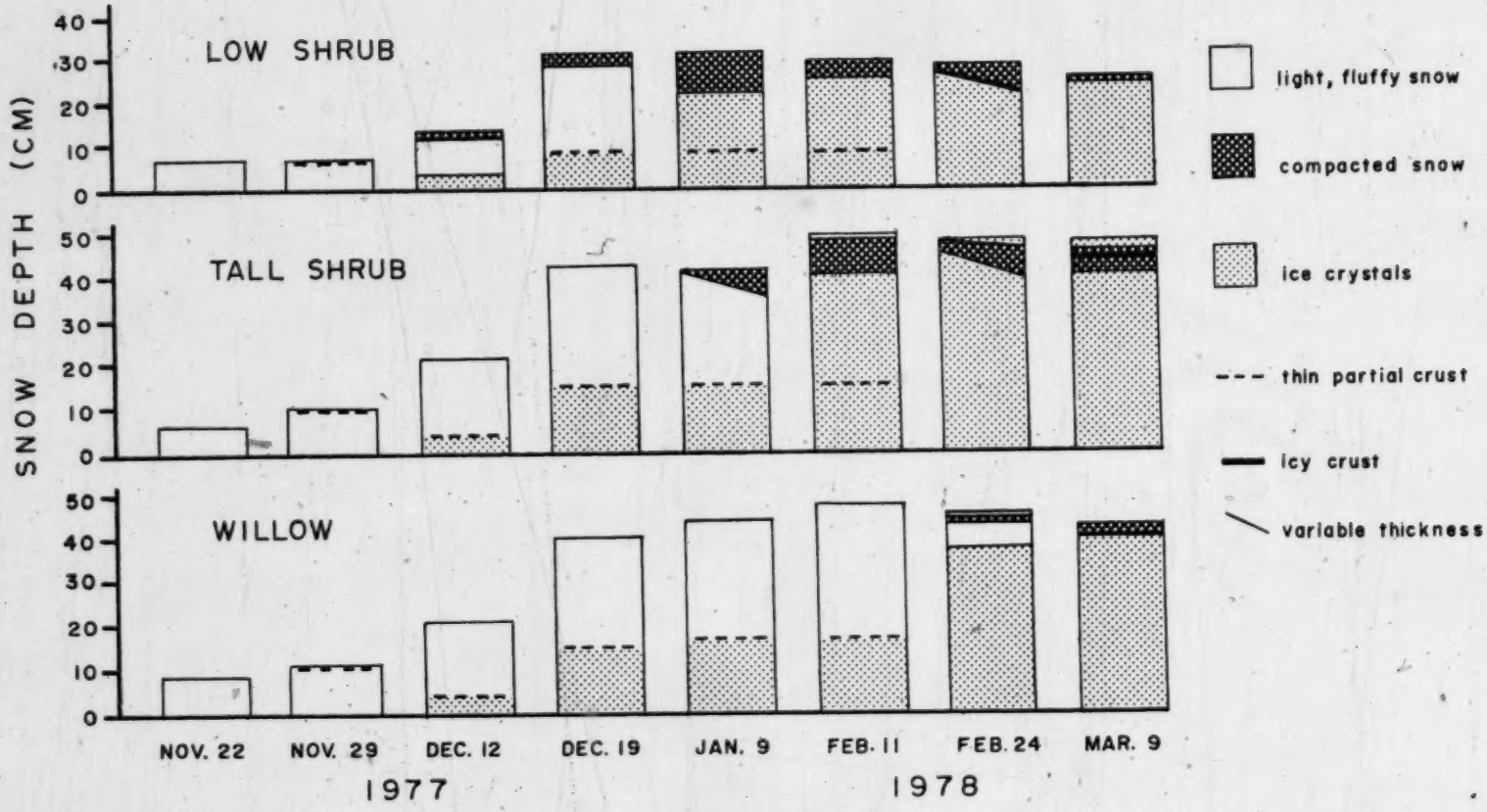


Figure 8. Depths and condition of snow in low shrub (snowberry), tall shrub (silverberry, rose) and willow throughout the winter on the Duperow study area, 1977-78.

Characteristics of Grouse Roosts in Snow

Data on snow-roosts were not collected until the second year of the study. Grouse used snow roosts from mid-December through the first week of March 1977-78. They did not roost under the surface unless the depth of the snow was at least 19 cm. On several occasions tracks indicated that grouse dug in snow less than this depth, but abandoned the excavation and tried other locations until a suitable site was found. This also happened if they encountered a thick wind-packed crust or ice layer less than 20 cm below the surface. Not one roost out of 121 examined was in less than 19 cm of snow.

In 1976-77 snow depth (Figure 9) was adequate for roosting from December 17 to March 6 (79 days). The following winter depths were adequate from December 12 to March 21 (100 days).

Grouse usually walked the last few meters to a site used as a snow roost. Evidence of flying into a snowdrift for the purpose of roosting was recorded in only 3 out of 116 (2.6%) roosts. Cross section of a typical snow roost is illustrated in Figure 3. The grouse digs a tunnel varying in length from 20 to 260 cm approximately 6 cm below the surface. At the end of the tunnel it digs a chamber slightly larger than body size. All excavated snow is pushed into the tunnel behind the grouse. In some cases snow completely blocks the tunnel; in others the top 1 cm

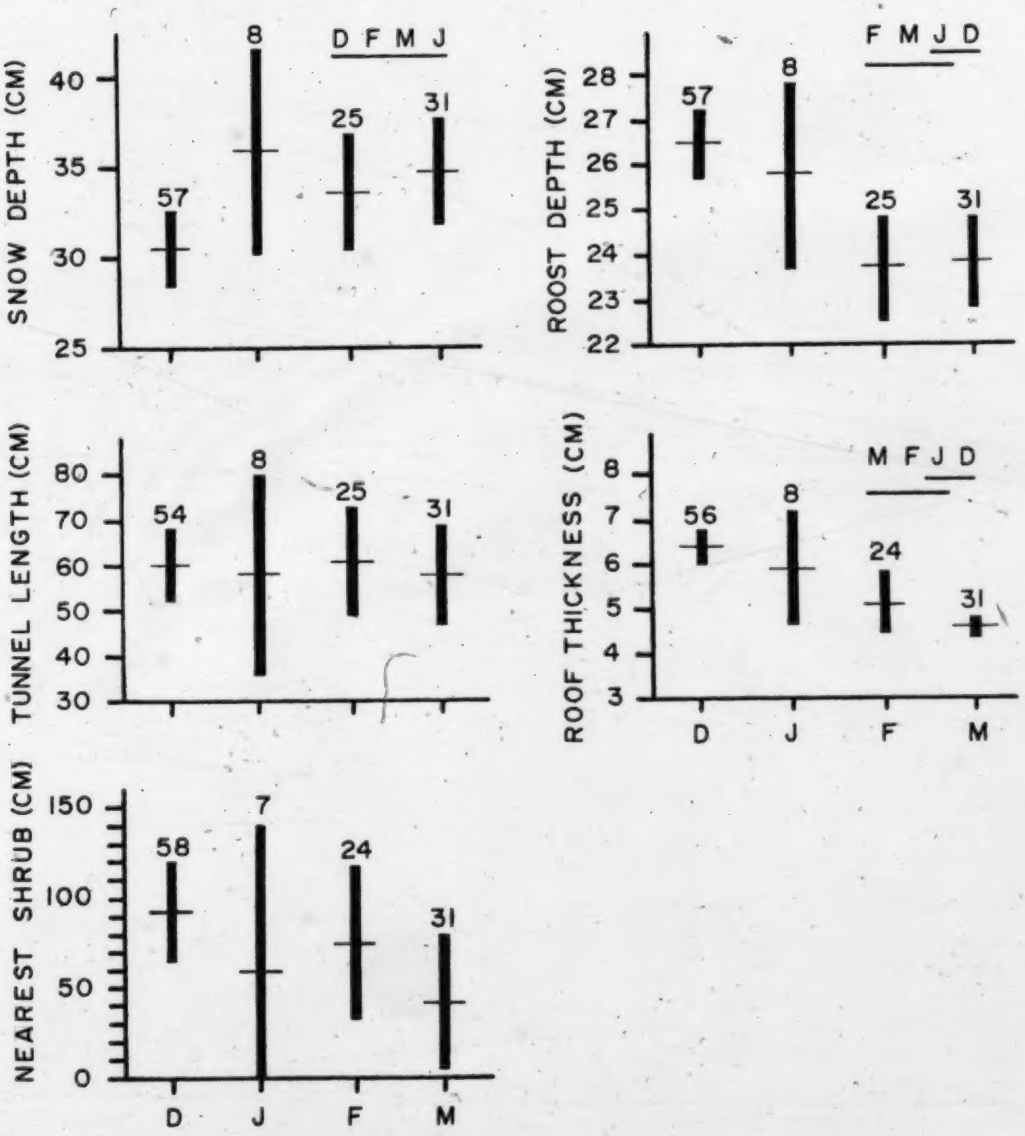


Figure 9. Characteristics of snow-roosts and the associated environment. Horizontal lines are means and vertical bars are the 95% confidence intervals. Numbers above bars are sample sizes. Months sharing a line beneath them are not significantly different (Duncan's Multiple Range Test a 0.05 probability level). No differences were found in the mean lengths of the roosts from December to March or in the mean distances to the nearest shrubs.

of the tunnel remains open. Occasionally one or two holes 2-3 cm in diameter were observed in the roof of the tunnel. Formozov (1973) observed similar holes in tunnels dug by hazel grouse and suggests that the grouse may be measuring snow depth by poking its head through to the surface. Compacted snow in the tunnel becomes harder than the surrounding snow. This discourages birds from leaving the roost through the entrance. When they leave they simply dig through the roof, which is 5-6 cm thick, or fly out, especially if disturbed.

No evidence was observed of grouse using a roost more than once although they were sometimes flushed from roosts within a few meters of an old roost. A roost is of no value after it has been used because the entrance tunnel becomes blocked by compacted snow, the exit hole exposes the roost chamber directly to the elements and melting of the walls from body heat decreases their insulating value. Digging a new roost is accomplished in a matter of minutes. Although not a natural situation, a wounded grouse which I tracked dug a roost in less than 5 minutes.

Members of a covey roost in the same general area, but in separate tunnels. Although the distance between roosts was found to be as short as 0.5 m the mean distance between roosts (n=53) was 4.8 m.

Mean snow depth at roost sites varied from 30.5 to 35.9 cm but differences among months were not significant

(Figure 9). Mean roost depths in December (26.5 cm) were significantly greater than mean depths in February (23.7 cm) and March (23.8 cm). Similarly, mean roof thicknesses were significantly greater in December (6.4 cm) than in February (5.1 cm) and March (4.6 cm). Mean length of the roost tunnel varied from 46.6 to 58.0 cm but differences among months were not significant.

The distance of a roost from the nearest shrub was measured as an index of vegetation density. Mean distance to the nearest shrub varied from 43.1 to 93.6 cm but differences were not significant. Vegetation above the snow was sparse. Even in March the mean distance to the nearest shrub was 43 cm which is equivalent to 3.1 stems/m^2.

Silverberry was the most common shrub recorded at roost sites. It was the nearest stem at 58% of roosts followed by snowberry (17%), rose (14%), willow (8%), aspen (2%) and choke cherry (1%).

Only 3% of the roosts examined were located in snow which had a surface crust. At 36% of the roosts there was a slight crust 15-20 cm below the surface and at 42% there was a slight crust 2-6 cm below the surface. These crusts usually were less than 5 mm thick and did not appear to hamper digging by grouse. The remaining 19% of roosts were located in soft snow with no crust.

On several occasions I observed that grouse had rested on the surface in a body-sized depression in the snow. In

most cases the snow was too shallow (less than 20 cm) for a burrow-type of roost. These surface roosts were common in November and early December before snow depths averaged 20-25 cm. They were rarely observed after mid-December except on dancing grounds. On these areas a shallow depression was dug on the leeward side of a small snowdrift, tuft of grass or shrub, presumably within a male's territory since the depressions were spaced out over the display area.

Seasonal and Daily Habitat Use

Use of major habitat types by grouse changed through the day and seasonally. Figure 10 illustrates some of the variations in use during autumn, winter and spring. Observations of birds on dancing grounds have been omitted from this analysis because they might bias the results; locations of these grounds were known and grouse could be found here whenever an effort was made to check them. Use of gravel roads increased by a factor of 5 between autumn (5%) and winter (26%) then dropped again in spring (7%). Cultivated fields received highest use in the autumn (57%) but dropped in winter (35%) and again in spring (26%). The use of the grassland habitat type dropped from autumn (14%) to winter (6%) but increased again in spring (28%). Low shrubs received the lowest use of all the habitat types (0-5%). Tall shrub habitat received steady use through all three seasons and was highest in winter (22%). Use of trees (aspen bluffs) dropped from autumn (16%) to winter (6%) and increased again in spring (19%).

Variations in the use of major habitat types during three periods of the day in winter are illustrated in Figure 11. Gravel roads, cultivated fields and tall shrubs received high use throughout the day. Use of tall shrubs and grassland increased from morning to evening and use of roads and cultivated fields decreased.

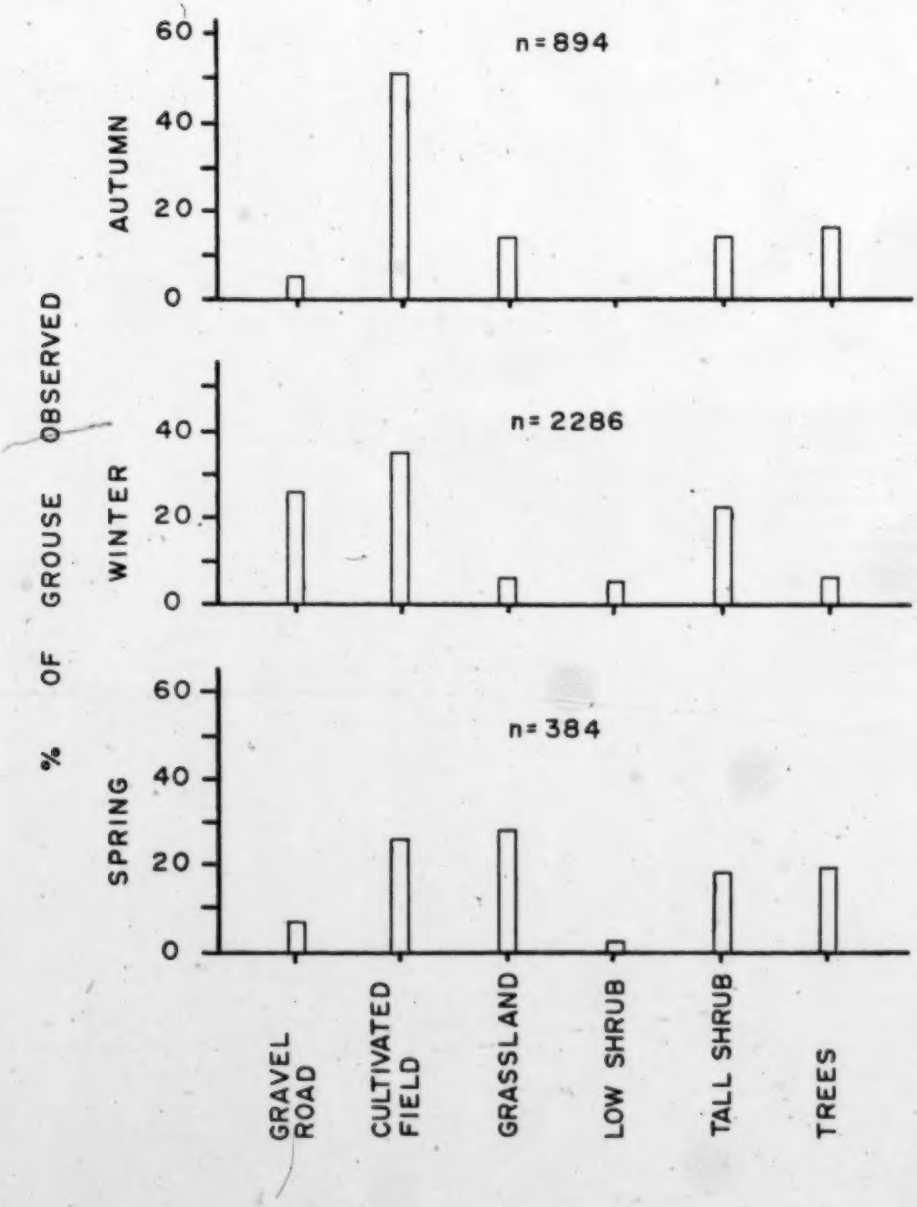


Figure 10. Changes in use of major habitat types by sharp-tailed grouse during autumn, winter and spring.

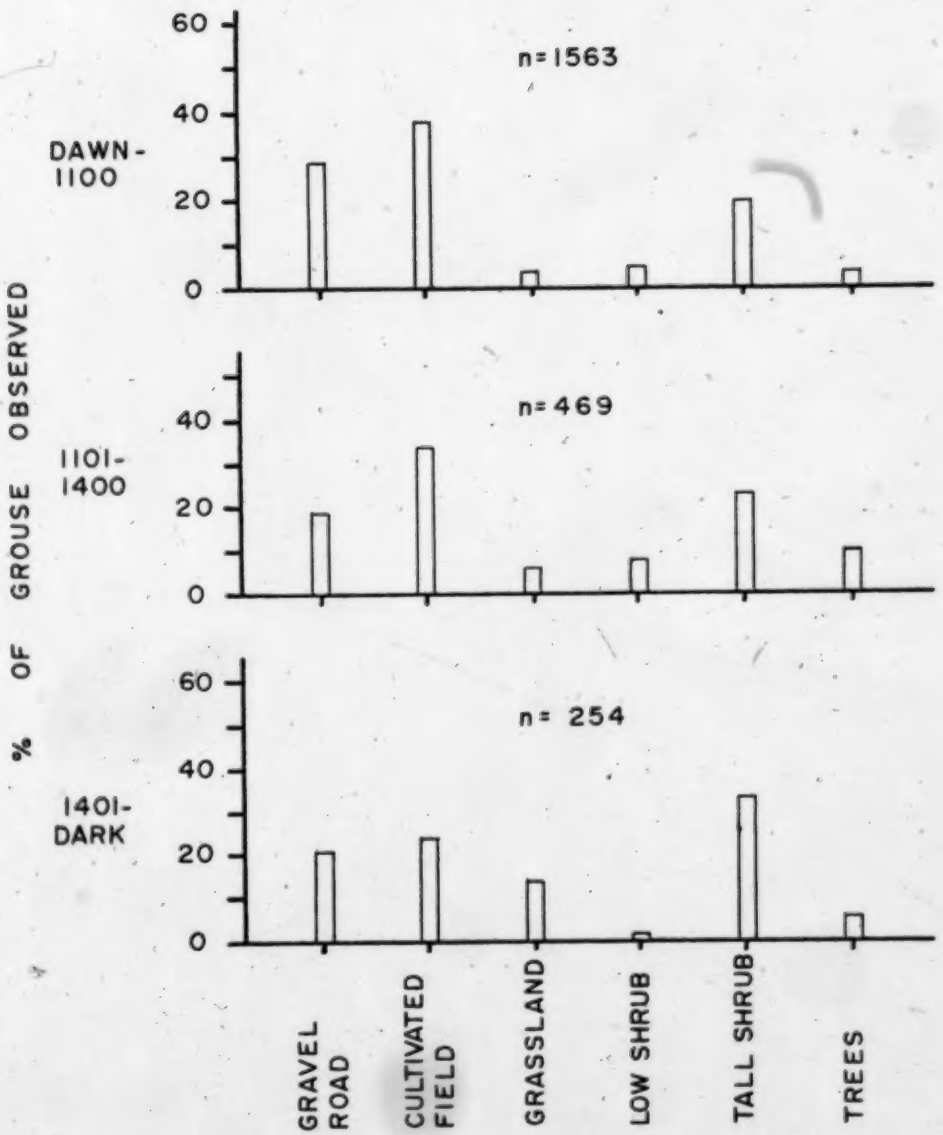


Figure 11. Changes in use of major habitat types by sharp-tailed grouse during three periods of the day during winter.

Daily Behavior in Winter

Figure 12 compares activities of sharp-tailed grouse during 3 periods of the day in winter. The information may be somewhat biased because it was far easier to observe and classify birds as feeding and picking grit than birds which were loafing or roosting in snow. Birds in the latter category could only be classified if they were flushed from roosts.

Feeding and picking grit were the activities most commonly observed. The percentage of grouse feeding remained relatively constant throughout the day. Picking grit decreases from early morning to mid-afternoon.

The number of grouse observed per hour during winter decreased from 17.10/hr in the period dawn to 1100 hrs to 5.25/hr in the period 1101 to 1400 hrs and to 2.72/hr between 1401 to dark.

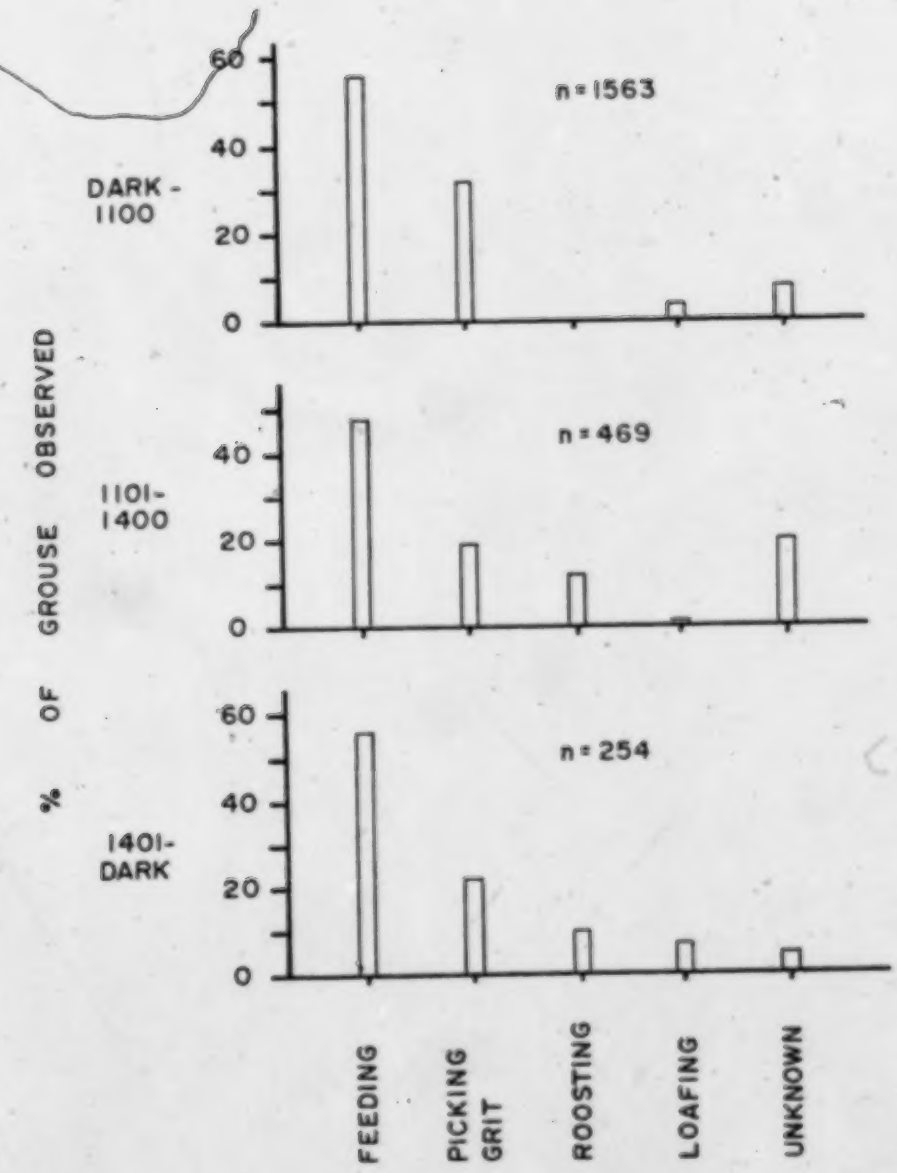


Figure 12. Changes in the activities of sharp-tailed grouse during three periods of the day during winter.

Food Habits

Crop contents were analyzed volumetrically and by dry weight (Table 3, Figure 13). Invertebrates were a very minor part of the diet, plant material made up over 99% of the foods eaten by sharp-tailed grouse from September to May. Because of the small sample sizes in September and May, the data have been included with those from October and April, respectively.

Berries, particularly silverberry, juniper, snowberry and rose, constituted the largest portion of the foods used by grouse. Silverberry received the highest use from December to March (Table 4). Juniper was eaten through the winter but was most important in early autumn and spring. The drop from December through February likely resulted because snowfall reduced the availability. Rose formed a major portion of the diet, but only in January. Snowberry appeared consistently between December and March, but in lesser amounts than other species.

Buds were important in the diet only from December to March. Chokecherry buds were most commonly eaten. Birch *(Betula occidentalis)* catkins (primarily seed catkins) were found only in November but were probably used throughout the winter in the areas where they were available; few grouse were collected from the areas with birch. Aspen catkins formed a major part of the diet in April and May.

Green leaves were important in autumn. Leaves and

Table 3. Foods of sharp-tailed grouse as determined from analysis of crop contents.

	Sept.-Oct.		November		December		January		February		March		April-May	
	% Vol.	% Dry Wt.	% Vol.	% Dry Wt.	% Vol.	% Dry Wt.	% Vol.	% Dry Wt.	% Vol.	% Dry Wt.	% Vol.	% Dry Wt.	% Vol.	% Dry Wt.
Seeds (Cultivated Grains)	25.6	41.7	47.9	64.0	42.2	51.5	19.6	24.0	30.3	45.6	14.6	24.5	-	-
Berries	39.5	47.7	18.8	18.7	51.1	44.3	65.1	62.7	46.6	42.8	51.0	54.0	12.3	31.9
Buds	0.4	0.4	2.0	1.8	5.1	3.8	14.4	13.0	8.9	7.4	11.8	12.6	1.0	1.5
Insects	0.8	0.7	t	t	-	-	-	-	-	-	t	t	t	0.2
Catkins	-	-	7.4*	8.1*	-	-	-	-	-	-	-	-	44.3**	33.0**
Green Leaves and Flower Heads	33.7	9.5	23.9	7.4	1.6	0.4	0.9	0.3	14.2	4.2	22.6	8.9	42.4	33.4

* Birch flower catkins and seed catkins. ** Aspen catkins.

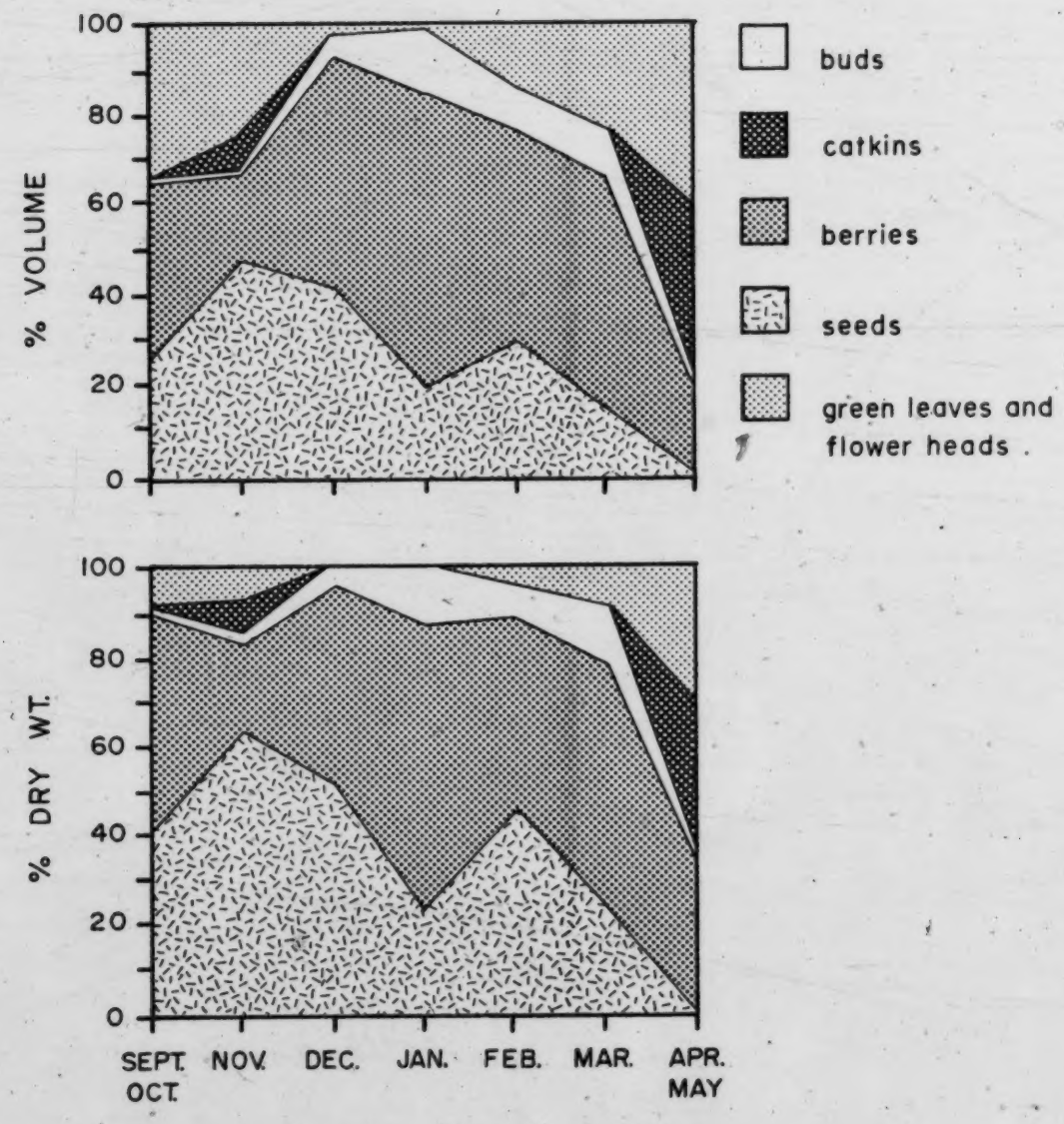


Figure 13. Foods of sharp-tailed grouse from September to May.

Table 4. Foods of sharp-tailed grouse as determined from crop contents (percent dry weight).

ANIMAL MATTER	PERCENT TOTAL DRY WT. Sept. Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April May
Grasshoppers *(Orthoptera)*	0.6	t	-	-	-	-	-
Beetles *(Coleoptera)*	0.1	-	-	-	-	t	0.2
Spiders *(Arachnida)*	t	-	-	-	-	-	-
Ants *(Hymenoptera)*	-	-	-	-	-	-	t
True Bugs *(Hemiptera)*	t	-	-	-	-	t	-
Insect Larvae	-	-	-	-	-	t	-
Subtotal	0.7	t	-	-	-	t	0.2
PLANT MATERIAL							
SEEDS							
Wheat	15.0	28.8	18.7	14.2	16.5	10.0	-
Oats	18.1	5.3	12.3	7.1	10.1	9.0	-
Rye	-	7.3	14.2	2.7	0.2	3.4	-
Barley	5.9	14.9	0.3	-	9.8	2.1	-
Buckwheat	2.7	7.6	6.2	t	8.9	0.1	-
Subtotal	41.7	63.9	51.7	24.0	45.5	24.6	-
BERRIES							
Silverberry	7.6	4.8	22.5	22.4	17.3	20.3	-
Snowberry	0.8	0.6	9.0	9.0	11.7	7.9	2.2
Rose	0.8	0.1	8.6	23.6	5.1	2.7	-
Juniper	36.1	13.1	4.2	7.5	8.6	21.3	29.6
Bearberry	2.4	-	-	-	-	1.9	-

	PERCENT TOTAL DRY WT.						
BERRIES (con'td)	Sept. Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April May
Choke Cherry	-	-	0.1	0.1	-	-	-
Saskatoon	-	-	-	t	-	-	-
Gooseberry *(Ribes sp.)*	-	-	-	t	-	-	-
Subtotal	47.7	18.6	44.4	62.6	42.7	54.1	31.8
BUDS							
Choke Cherry	0.1	0.3	1.2	6.6	3.8	11.9	0.1
Saskatoon	0.1	0.4	1.1	0.8	2.6	0.2	-
Aspen	0.2	0.1	1.1	3.8	0.3	-	-
Pin Cherry *(Prunus pennsylvanica)*	-	-	0.1	1.7	0.6	0.2	-
Buffaloberry *(Shepherdia canadensis)*	-	-	-	t	-	-	0.3
Willow	-	0.6	-	t	0.1	-	-
Silverberry	-	t	0.3	0.1	-	0.1	0.6
River Birch	-	0.4	-	-	-	-	-
Balsam Poplar	-	-	-	-	t	-	-
Unidentified	-	-	t	-	-	0.2	0.5
Subtotal	0.4	1.8	3.8	13.0	7.4	12.6	1.5
CATKINS							
Aspen	-	-	-	-	-	-	32.8
River Birch	-	8.1	-	-	-	-	-
Unidentified	-	-	-	-	-	-	0.1
Subtotal	-	8.1	-	-	-	-	32.9
FLOWERS AND LEAVES							
Dandelion	2.3	0.2	-	-	1.5	-	27.4

....

FLOWERS AND LEAVES (cont'd)	PERCENT TOTAL DRY WT. Sept. Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April May
Perennial Sowthistle *(Sonchus arvensis)*	1.4	0.9	-	-	-	t	0.3
Prairie Crocus *(Anemone patens)*	-	-	-	-	-	-	0.5
Grass or Wheat	0.7	t	0.2	t	0.5	0.8	t
Unidentified Leaves	5.1	6.3	0.2	0.3	2.2	8.1	5.1
Subtotal	9.5	7.4	0.4	0.3	4.2	8.9	33.3
Total Dry Weight of All Crop Contents	67.8 gm	107.1 gm	344.4 gm	516.4 gm	304.7 gm	66.6 gm	48.6 gm
Sample Size	20	13	21	27	24	15	21
Mean Dry Weight Per Crop	3.4 gm	8.2 gm	16.4 gm	19.1 gm	12.7 gm	4.4 gm	2.3 gm

t = trace (<0.1%)

flower heads, especially dandelion *(Taraxacum officinale)* were also used extensively in April and May.

Grains formed a major portion of the diet in every sampling period except April and May. In mid-winter grouse were observed feeding in stubble fields that were blown clear of snow, or where the snow had melted off south-facing slopes and knolls. Grouse would occasionally scratch through a few cm of snow to uncover grain but no evidence was found of them digging more deeply in search of food in the manner of gray partridge. Wheat and oats were the grains used most frequently, but rye, barley and wild buckwheat *(Polygonum* sp.*)* also formed a significant portion of the diet in some months (Table 4). The availability of grain undoubtedly affected the use of native vegetation in local areas.

Food Habits and Preferences as Determined From Tracking Grouse in Snow

Sharp-tailed grouse tracks were followed for 623.75 m in 1977 and 870.75 m in 1978. Species of plants present and utilization were recorded at 0.25 m intervals along the 1494.5 m (a total of 5978 points). No vegetation was present above the snow at 3717 sampling points (62.2%). At least 2402 stems were recorded along the transects, which covered 374 m^2. Since only the presence of a species was recorded, not the number of stems an exact density cannot be calculated. However, the minimum density was at least 6.4 stems/m^2 which is more than double the plant density on sites used as snow roosts (3.1 stems/m^2).

Rose, snowberry and silverberry were the most common species recorded at feeding sites and were present in approximately equal quantities (24 - 26%, Table 5), compared to snow roost sites where silverberry was the dominant species (58%).

Data on browse preferences collected while tracking grouse are summarized in Table 6. If buds and berries are browsed randomly the percentage of plants browsed should be proportional to the occurrence of that species. If percent utilization is greater than percent occurrence, it suggests grouse are actively seeking that species. If the percent utilization is less than percent occurrence, grouse are avoiding that species. Rose hips made up 7% of the available food on the transects and were used in the same proportion

Table 5. Plant species composition and browse availability on areas used by sharp-tailed grouse for feeding during winter as determined from tracking in snow.

	Berries			Buds		
	Rose	Juniper	Snowberry	Aspen	Choke cherry	Silverberry
Percent of plots with species present.	26	3	24	5	17	24
Percent of plots containing that species with browsable plants.	13	100	14	73	79	85
Percent of plots with browsable plants which were browsed.	43	90	61	85	81	2

Totals in rows do not equal 100% because some plots contained more than one species.

Table 6. Browse preferences of sharp-tailed grouse during winter as determined from tracking in snow.

	Berries			Buds		
	Rose	Juniper	Snowberry	Aspen	Choke cherry	Silverberry
Occurrence (percent of total browsable plants)	7	5	7	8	28	43
Utilization (percent of total browsed plants)	7	12	10	16	52	2
Nature of Selection	0	+	+	+	+	-

0 Suggests no selection; utilization was proportional to occurrence.

+ Suggests positive selection; utilization was greater than what would be expected by random browsing.

- Suggests negative selection; utilization was less than would be expected by random browsing.

(7%) that they were available. Chokecherry buds, on the other hand, made up 28% of the available browse but accounted for 52% of all items browsed, suggesting a positive selection for that species. Similarly, grouse selected aspen buds, juniper berries and snowberries. Use of silverberry buds was much less than would be expected if grouse were browsing randomly.

Snow depths were recorded at 7 feeding sites. Mean depth at one site in December was 47 cm. At two sites in each of January, February and March mean depths were 42, 45 and 45 cm respectively.

Protein and Moisture Content of Major Food Items

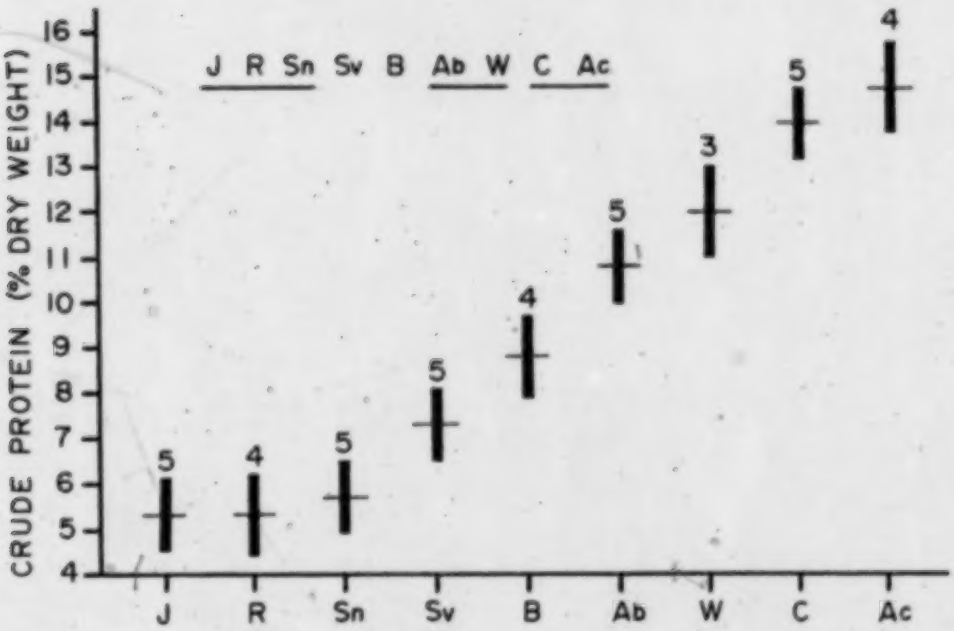
Major food items of sharp-tailed grouse were analyzed for crude protein and moisture content (Table 7). Berries had the lowest protein content (3-7%) and aspen and willow catkins the highest (15-25%). Buds were intermediate (11-14%). There were no significant differences in the protein content of rose, snowberry or juniper berries, but these three species were significantly lower than other items analyzed (Figure 14). Berries of silverberry and birch seeds had a significantly higher protein content and were significantly different from each other. Aspen and willow buds had protein contents significantly greater than species noted above, but were similar to each other. Protein content of chokecherry buds and aspen catkins were similar to each other, but significantly higher than the other materials analyzed. Bearberry *(Arctostaphylos uva-ursi)* had the lowest protein content of any species while that of Saskatoon buds *(Amelanchier alnifolia)* was similar to that of aspen buds. The protein content of willow catkins was almost double the next highest item. Crude protein of grains in Saskatchewan may run up to 15% for wheat, 13% for oats, 13% for barley and 14% for rye (Subcommittee on Feed Composition 1971). Protein in dandelion leaves varies from 17 to 23% depending on the stage of development (Subcommittee on Feed Composition 1971).

Moisture content was lowest in silverberry berries (20%), highest in aspen catkins (70%) and ranged from 39

Table 7. Crude protein and moisture content of native plant species eaten by sharp-tailed grouse.

	Species	n	% Crude Protein	% Moisture
Berries	Bearberry	1	2.6	*
	Juniper	5	5.3	46
	Rose	4	5.3	39
	Snowberry	5	5.7	47
	Silverberry	5	7.3	20
Seed Catkins	Birch	4	7.9	*
Buds	Aspen	5	10.8	43
	Saskatoon	1	10.9	44
	Willow	4	12.0	44
	Choke cherry	5	14.0	46
Catkins	Aspen	4	14.8	70
	Willow	1	24.5	*

* not measured



J = juniper berries

R = rose hips

Sn = snowberry berries

Sv = silverberry berries

B = birch seeds

Ab = aspen buds

W = willow buds

C = chokecherry buds

Ac = aspen catkins

Figure 14. Crude protein content of some native plant species eaten by sharp-tailed grouse during winter. The horizontal lines are means and the vertical bars are the 95% confidence intervals. Numbers above bars are sample sizes. Species sharing a line beneath them are not significantly different (Duncan's Multiple Range Test at 0.05 probability level).

to 47% in the other samples (Table 7). Dandelion leaves have a moisture content of up to 85% (Subcommittee on Feed Composition 1971).

Seasonal Changes in Body Components and Fat Depots

Most of the statistical analysis in this section was based on data from males because the sample size from females was so small.

There were no significant differences in mean weights of adult or juvenile males when comparing monthly samples between 1976/77 and 1977/78 (Table 8). Therefore, data from the 2 years were combined within each age group. Adults were significantly heavier than juveniles in October and November, but there were no significant differences in September, or December through April. In November mean weights of pectoral muscles of adult males were significantly heavier than those of juveniles. Mean weights of leg muscles of adults were heavier than those of juveniles in December. Adults also had larger fat depots than juveniles in November. Because of these differences the data from adult and juvenile males were analyzed separately.

Mean body weights of adult males were lowest in September (Figure 15). Body weight increased significantly by November, decreased significantly between November and January, increased significantly between February and April then decreased significantly between April and May.

Pectoral muscles are a major component (28% - 31%) of total body weight. Trends recorded for changes in mean weights of pectoral muscles of adult males were similar to the trends in changes of body weight from September to

Table 8. Comparisons of body weight and components of male sharp-tailed grouse.

Comparisons	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Wet weight - adults between years	-	NS	-	NS	NS	NS	_	NS
Wet weight - juveniles between years	-	NS	-	-	NS	NS	NS	-
Wet weight - adults versus juveniles	NS	A>J	A>J	NS	NS	NS	NS	NS
Pectoral muscles - adults versus juveniles	NS	NS	A>J	NS	NS	NS	A>J	NS
Leg muscles - adults versus juveniles	NS	NS	NS	A>J	NS	NS	NS	NS
Wing length - adults versus juveniles	NS	A>J	A>J	NS	NS	NS	NS	NS
Fat depots - adults versus juveniles	NS	NS	A>J	NS	NS	NS	NS	NS

NS = not significant, $p<0.05$.

- = sample sizes too small to compare.

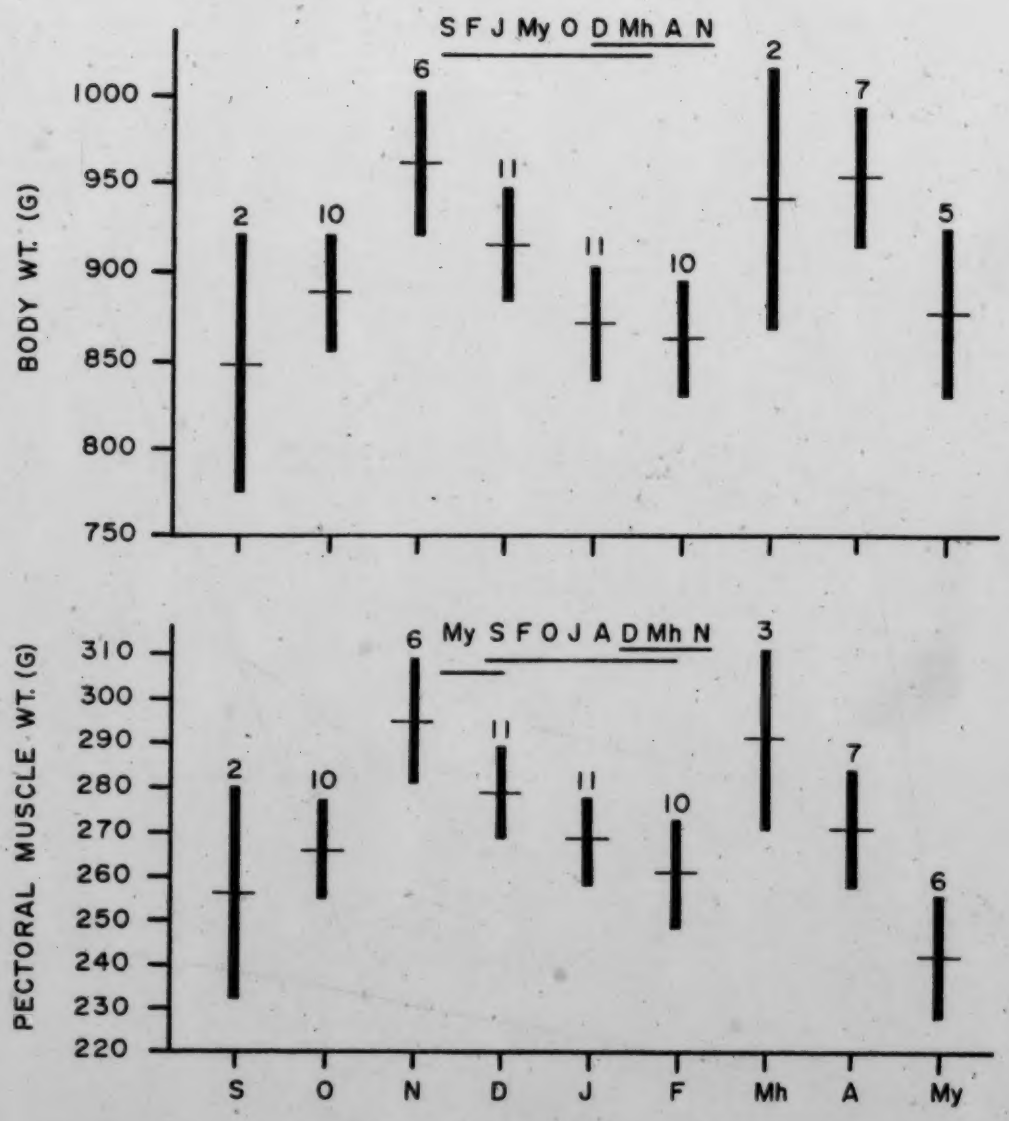


Figure 15. Body weights and weights of pectoral muscles of adult male sharp-tailed grouse. Horizontal lines are means and vertical bars are the 95% confidence intervals. Numbers above the bars are sample sizes. Months sharing a line beneath them are not significantly different (Duncan's Multiple Range Test at 0.05 probability level).

February (Figure 15). The increase between February and March was not significant but the decrease from March to May was significant.

Mean weights of fat extracted from sample depots followed trends similar to those of body weight and pectoral muscles (Figure 16). Fat reserves were significantly greater in November and December compared to other periods.

Leg muscles comprise 11% - 15% of the wet weight of a sharp-tailed grouse, but changes in leg muscles do not parallel changes in total body weight (Figure 16). There were no significant changes in weight from September through December, but a significant decrease occurred by January. Statistically significant increases occurred between February and March and between March and April. Leg muscles were 16% heavier in April and May than in September and 32% heavier than in January.

Mean body weights of juvenile males increased from September to December, decreased significantly from December to February and then increased significantly between February and March (Figure 17).

Mean weights of pectoral muscles increased from September to December, decreased from December to February and then increased from February to March (Figure 17). In contrast to changes in weight of pectoral muscles of adult males none of the changes in juveniles were significant.

Fluctuations in fat reserves of juveniles closely

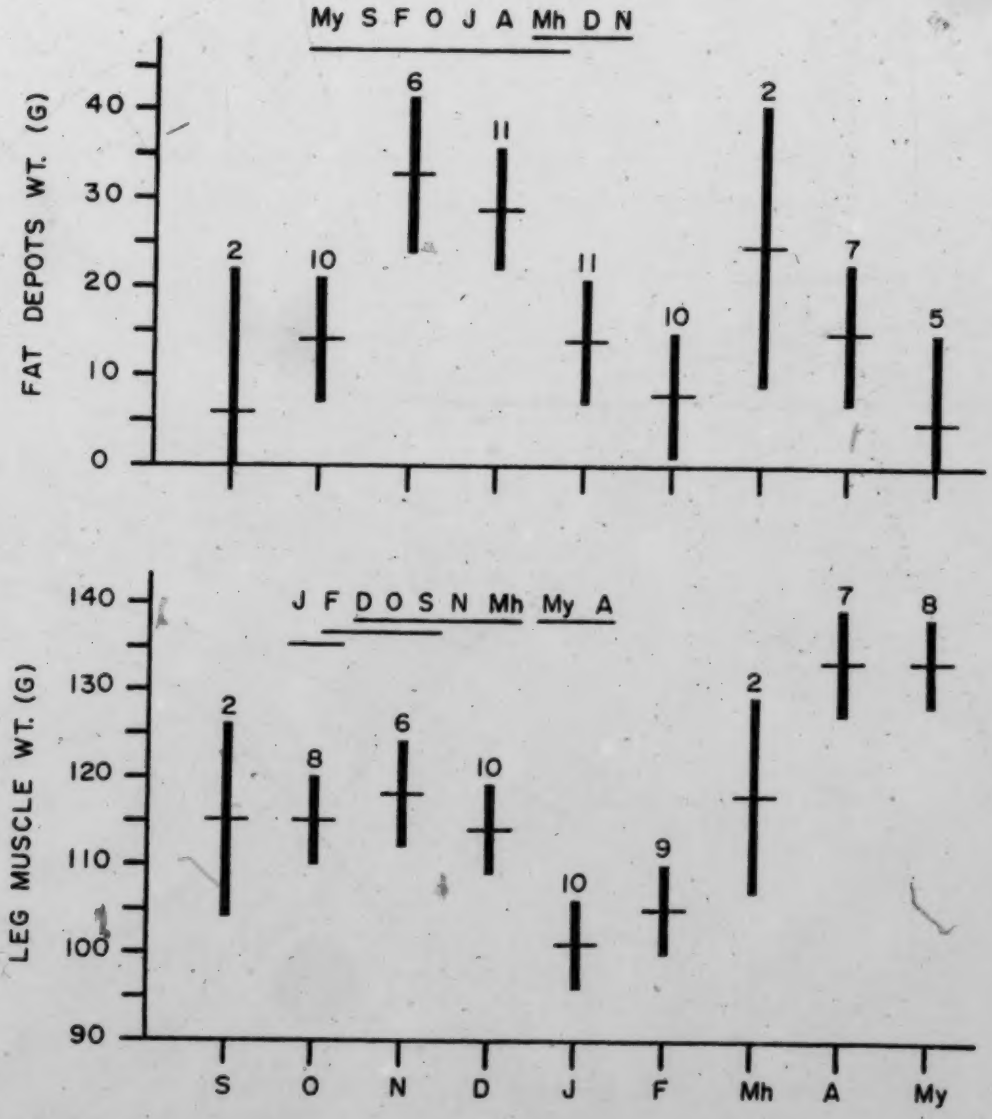


Figure 16. Weights of fat from three depots and weights of leg muscles of adult male sharp-tailed grouse. Horizontal lines are means and vertical bars are the 95% confidence intervals. Numbers above the bars are sample sizes. Months sharing a line beneath them are not significantly different (Duncan's Multiple Range Test at 0.05 probability level).

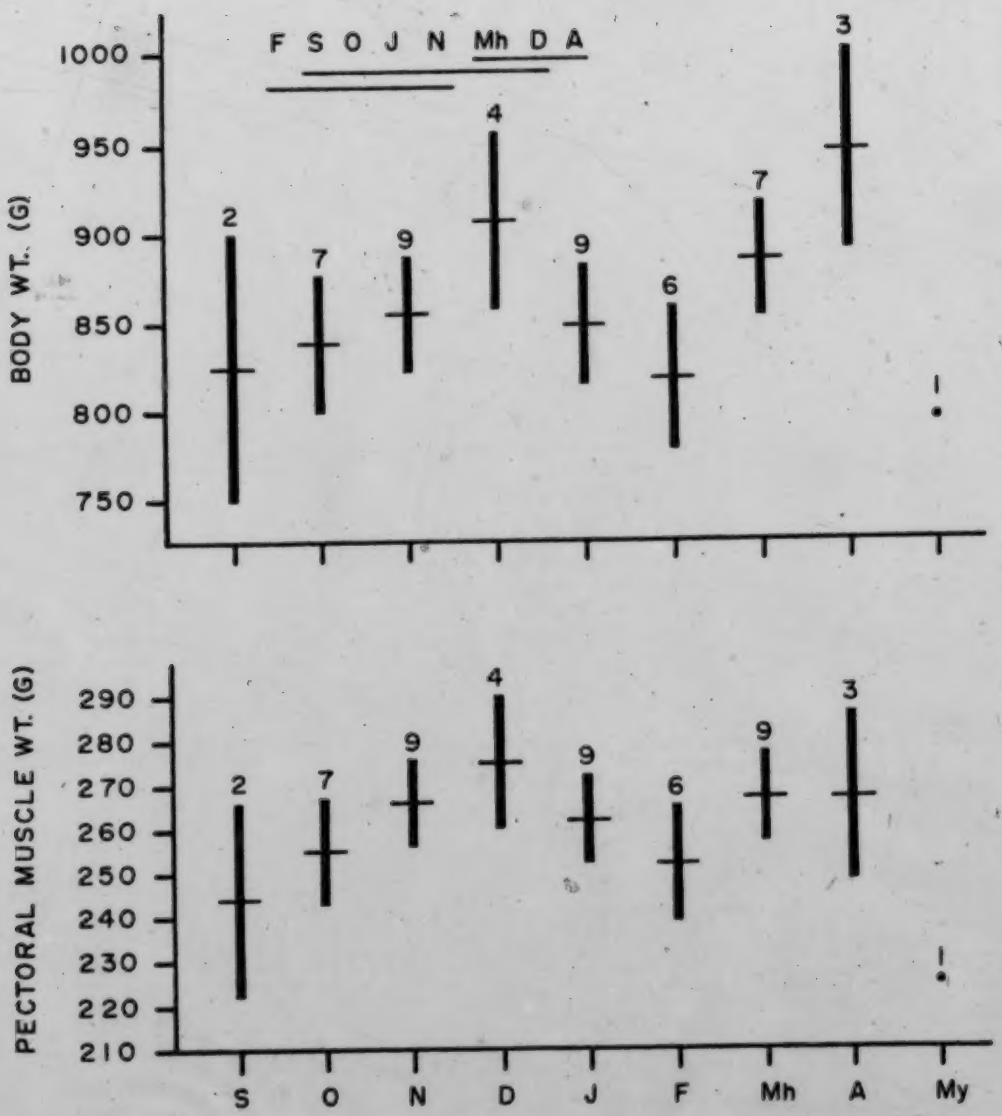


Figure 17. Body weights and weights of pectoral muscles of juvenile male sharp-tailed grouse. Horizontal lines are means and vertical bars are the 95% confidence intervals. Numbers above the bars are sample sizes. Months sharing a line beneath them are not significantly different (Duncan's Multiple Range Test at 0.05 probability level).

paralleled changes in adults (Figure 18). Reserves were significantly greater in December compared to other periods.

Changes of leg muscles of juveniles (Figure 18) showed similar trends to those recorded in adult males. The mean weights remained relatively constant from September to February and then increased significantly by April.

Changes in the width of the tail in males (Figure 19) paralleled changes in the weights of the leg muscles. The width of the tail was used as a measure of an increase in the muscle volume because the measurement was relatively simple and much quicker than dissecting the muscles and weighing them. There were no significant changes in tail width from September through December. The mean widths in January and February were not significantly different than in September, November and December, but were significantly less than in October. Mean width increased significantly from February to March and from March to April (26% increase between February and April). There were no significant changes from April to May.

Changes in the weight of the leg muscles and width of the tail parallel changes in the size of testes (Figure 19). The increase in width of the tail and weights of leg muscles between February and April may be related to hormonal stimulus or hypertrophy as a result of increased use of these muscles during courtship displays.

Mean body weights of females increased from October

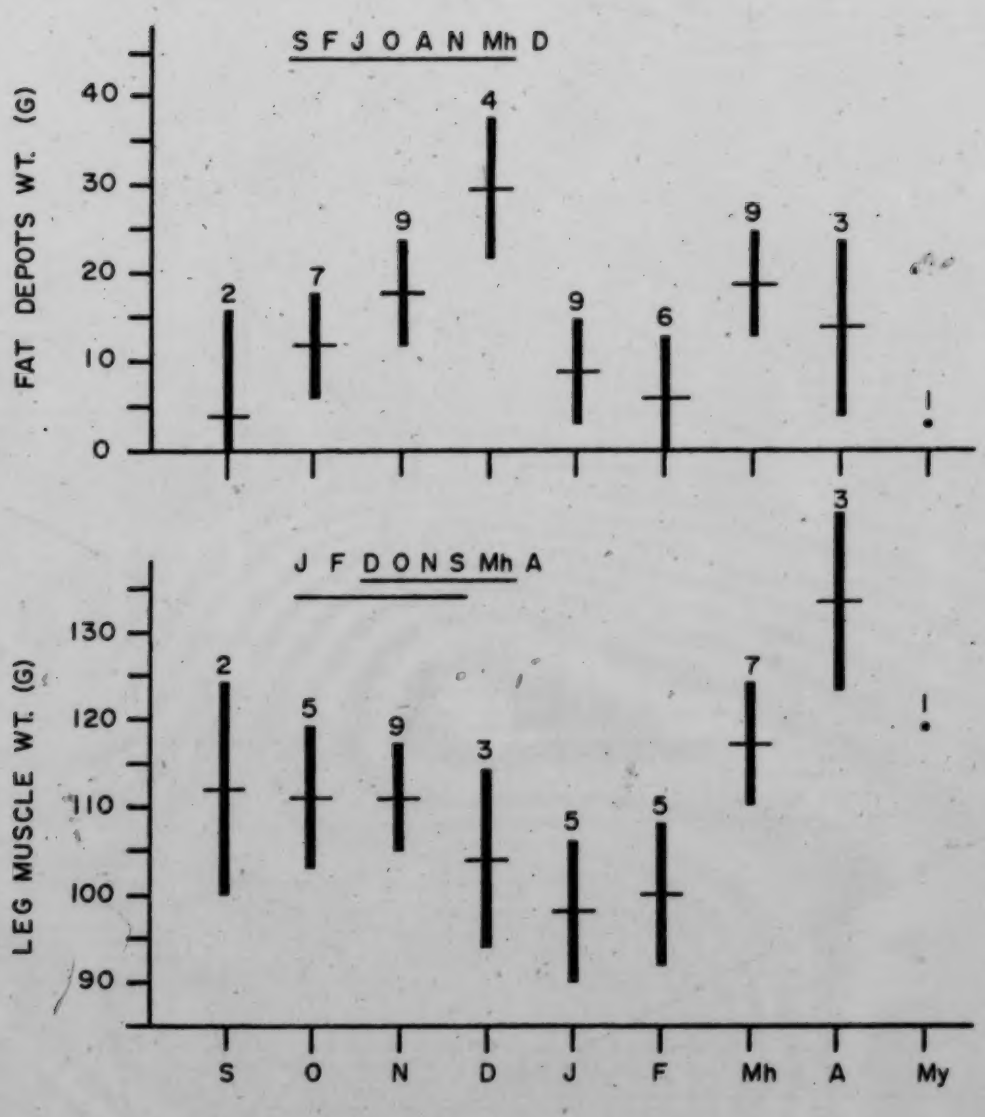


Figure 18. Weights of fat from three depots and weights of leg muscles of juvenile male sharp-tailed grouse. Horizontal lines are means and vertical bars are the 95% confidence intervals. Numbers above the bars are sample sizes. Months sharing a line beneath them are not significantly different (Duncan's Multiple Range Test at 0.05 probability level).

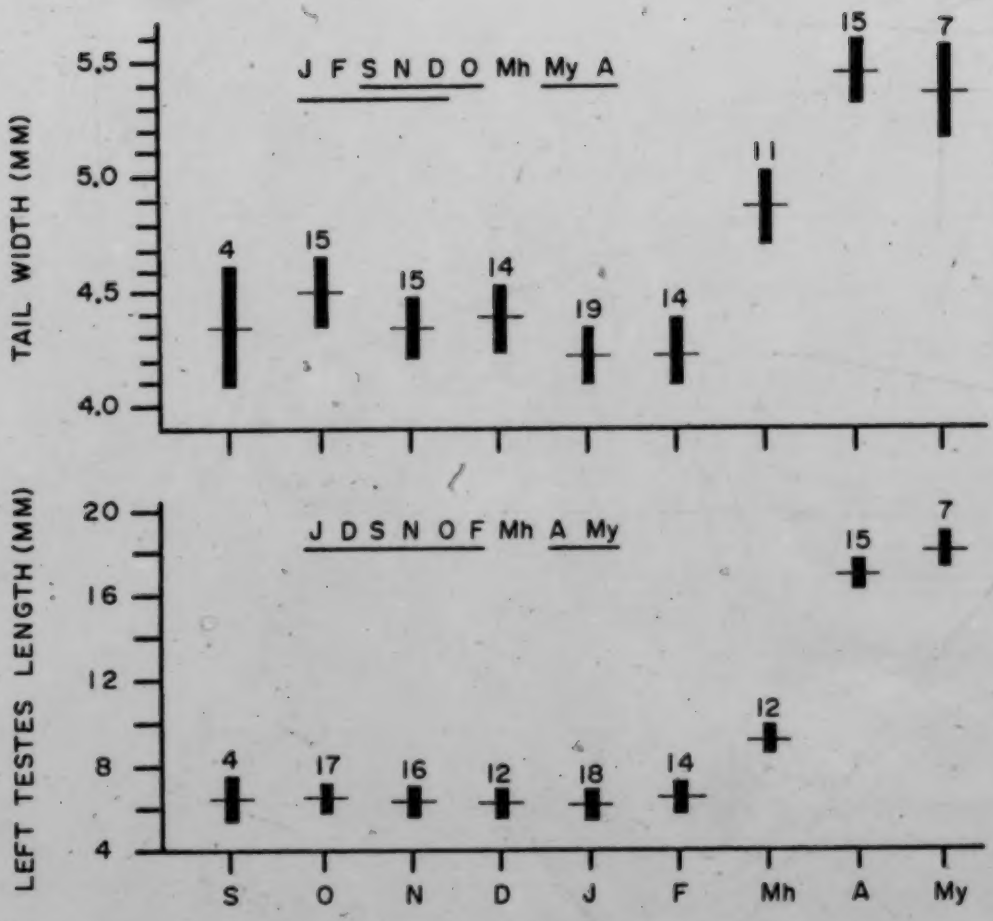


Figure 19. Widths of tail muscles and lengths of left testes of adult and juvenile male sharp-tailed grouse. Horizontal lines are means and vertical bars are the 95% confidence intervals. Numbers above the bars are sample sizes. Months sharing a line beneath them are not significantly different (Duncan's Multiple Range Test at 0.05 probability level).

to November (Figure 20). A significant decrease between November and February was followed by a significant increase from February to May.

Mean weights of pectoral muscles of females were significantly higher in November, April and May than in February (Figure 20). Changes in mean weights of fat depots paralleled changes in body weight (Figure 21). The only statistically significant change was the decrease from November to February.

Changes in leg muscle weights paralleled changes in total weight (Figure 21).

No significant differences were found in the tail widths of females between October and April.

Mean width of the oviduct varied between 3 mm and 5 mm from September to March. Width increased to 7 mm in April and 11 mm in May. Mean diameter of the largest follicle in the ovary was 1 mm or less between September and March, increasing to 3 mm in April and 20 mm in May.

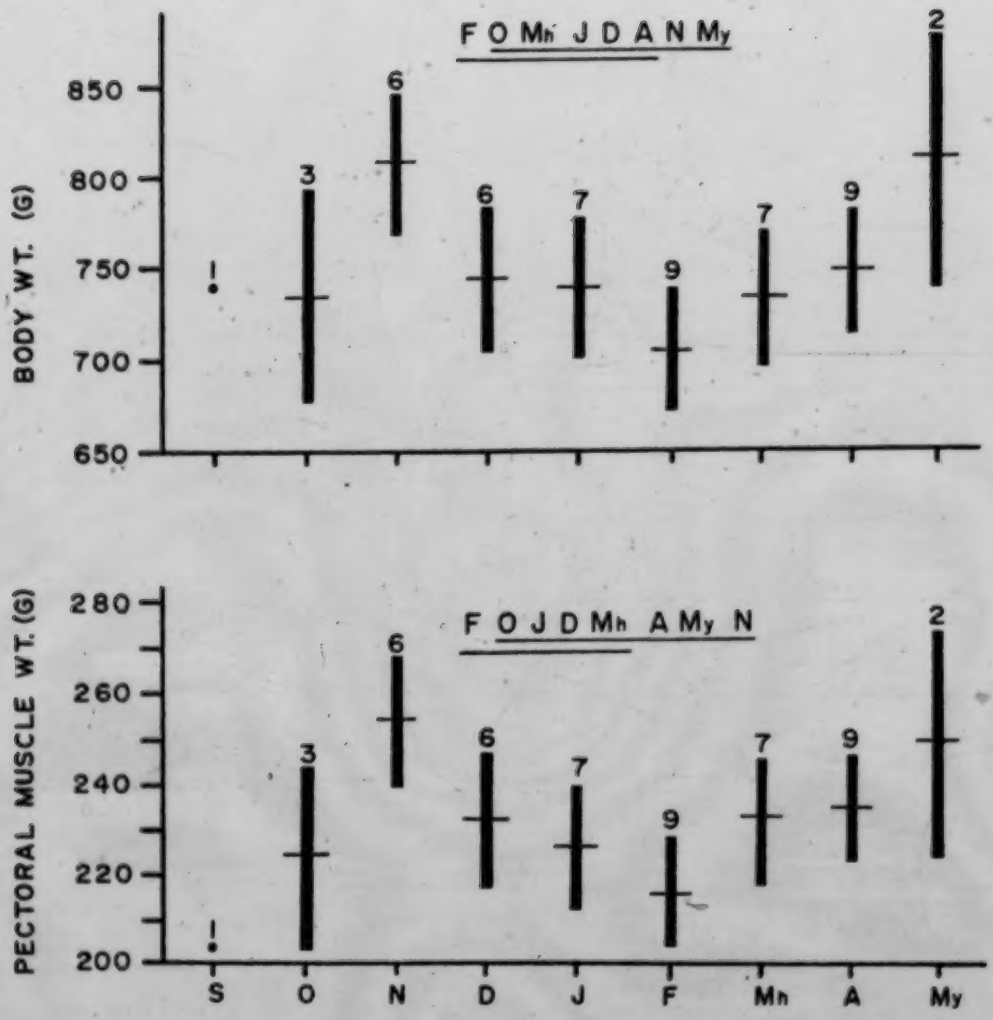


Figure 20. Body weights and weights of pectoral muscles of female sharp-tailed grouse. Horizontal lines are means and vertical bars are the 95% confidence intervals. Numbers above the bars are sample sizes. Months sharing a line beneath them are not significantly different (Duncan's Multiple Range Test at 0.05 probability level).

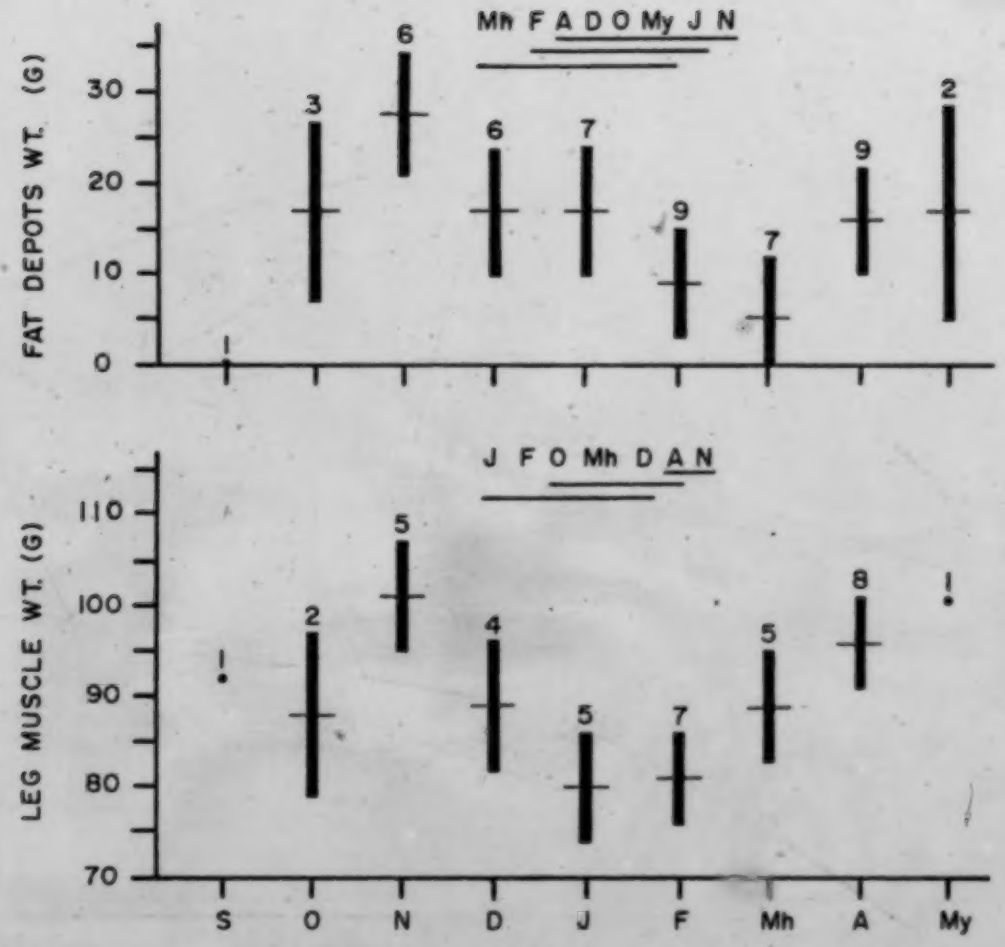


Figure 21. Weights of fat from three depots and weights of leg muscles of female sharp-tailed grouse. Horizontal lines are means and vertical bars are the 95% confidence intervals. Numbers above the bars are sample sizes. Months sharing a line between them are not significantly different (Duncan's Multiple Range Test at 0.05 probability level).

Changes were recorded in the lengths of the small intestine and caeca (Figure 22) and in the lengths of the large intestine and the weight of the gizzard and proventriculus (Figure 23) of male sharp-tailed grouse. No significant differences were observed between adults and juveniles during the different collection periods. Therefore the data from the two age groups have been combined.

The lengths of the small intestine were longest in December (127 cm) and shortest in May (113 cm). A significant decrease occurred between December and May.

Caeca were longest in February (112 cm) and shortest in September (89 cm). A significant increase recorded between September and January was followed by a significant decrease between February and May.

Large intestine lengths were greatest in February and April (15 cm) and shortest in November (13 cm). An increase between November and February was the only statistically significant change recorded.

The weight of the gizzard and proventriculus was significantly greater in January and February (25 g) than at other times of the year (October - 19 g, May - 17 g).

Changes in the gut of females were similar to the trends observed for males. However, the actual lengths were slightly shorter for females.

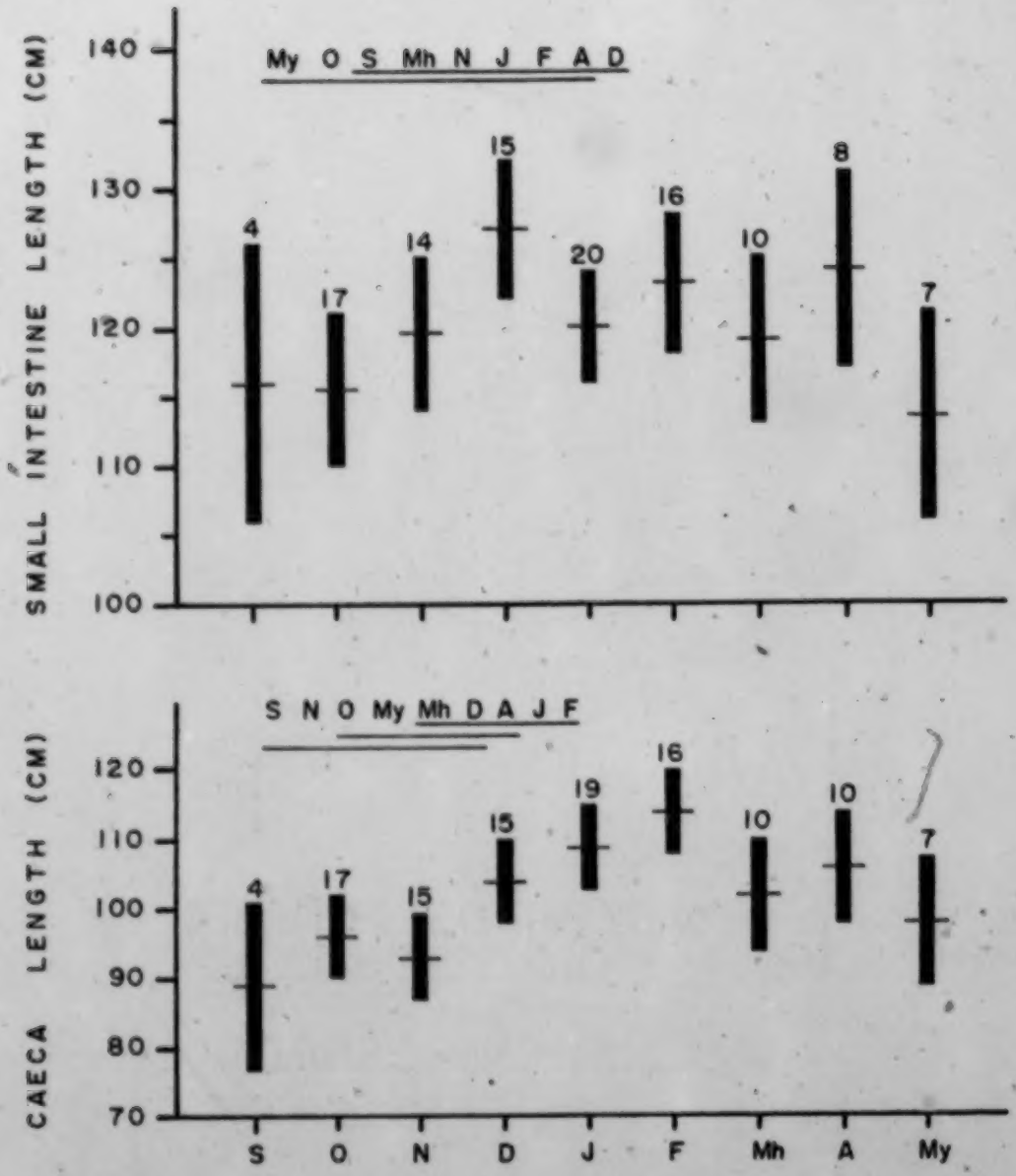


Figure 22. Lengths of the small intestine and caeca of male sharp-tailed grouse. Horizontal lines are means and vertical bars are the 95% confidence intervals. Numbers above the bars are sample sizes. Months sharing a line beneath them are not significantly different (Duncan's Multiple Range Test at 0.05 probability level).

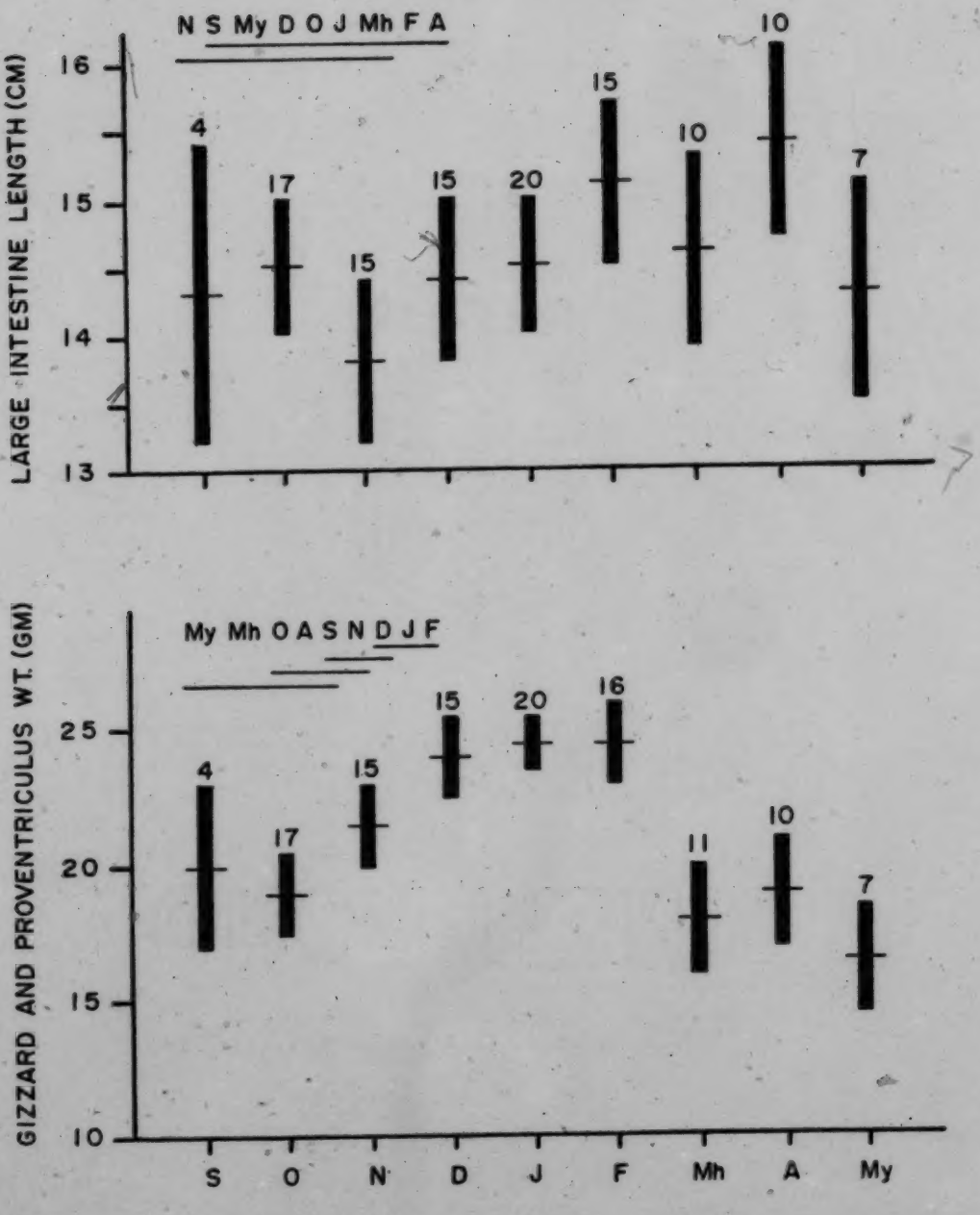


Figure 23. Lengths of the large intestine and weights of the gizzard and proventriculus of male sharp-tailed grouse. Horizontal lines are means and vertical bars are the 95% confidence intervals. Numbers above the bars are sample sizes. Months sharing a line beneath them are not significantly different (Duncan's Multiple Range Test at 0.05 probability level).

DISCUSSION

Densities of Breeding Males

Counts of male sharp-tailed grouse on dancing grounds are used to calculate male breeding densities and are also used as an index of population trends from year to year. Although Rippin and Boag (1974) demonstrated that a population of non-territorial males exists which may equal the number of territorial males, they did not determine the size of the area from which these "extra" males were coming. Whether these non-territorial males are present every year and in what proportion to the other sex and age groups in the population is unknown. Also, there is no information on the female segment of the population and there are no simple survey methods which have been developed to determine densities of breeding females or non-territorial males. If a significant portion of the grouse population is non-territorial then theoretically a large part of the population could be eliminated during the winter and spring which might not be detected by a survey of males on dancing grounds. If the ratio of non-territorial to territorial males is similar to that reported by Rippin and Boag (1974) the male population could drop by 50% without being detected during dancing ground surveys. Therefore, such surveys can only be used as a very general indication of population trends or for comparing populations on two different areas. Densities of males on dancing grounds should be considered <u>minimal</u> densities.

Actual densities could be up to four times that of territorial males.

The Duperow survey block supports a denser population (7.3 males/km^2 in 1977 and 6.5 males/km^2 in 1978) than most other blocks in southern Saskatchewan. In 1977 the average density on 44 survey blocks was 2.3 males/km^2, and in 1978 the average density on 40 survey blocks was 1.8 males/km^2 (Saskatchewan Tourism and Renewable Resources, 1977). The survey block used by Pepper (1972), which is located on similar habitat approximately 72 km northeast of the Duperow study area, supported a density of 2.0 males/km^2 in 1969 and 1.6 males/km^2 in 1977. In 1977 the only survey blocks in the province with higher densities than Duperow were Estevan-Cambria (11.2 males/km^2) and Val Jean (10.7 males/km^2) (unpublished data, Saskatchewan Tourism and Renewable Resources). Both of these blocks are located in the southern part of the province where habitat and weather conditions are different than at Duperow.

One of the major reasons for choosing the Duperow area for this study was that it supported a large enough grouse population that it could withstand a significant amount of collecting. The density in 1979 (9.1 males/km^2) was higher than the density in 1976 (7.5 males/km^2), when the study began. Thus it appears that the population was relatively unaffected by my collecting.

Sex and Age Ratios

The sex ratio of grouse collected at Duperow was heavy toward males even when males collected on dancing grounds were eliminated from the sample. Saskatchewan Tourism and Renewable Resources collects wings and tail feathers of sharp-tailed grouse to determine sex and age ratios for management purposes. Between 1966 and 1977 (unpublished data) the sex ratio ranged from 76 males/100 females to 154 males/100 females, and averaged 107 males/100 females. The sex ratio of sharp-tailed grouse trapped during the winter in Nebraska (Sisson 1976) was 163 males/100 females. However, Sisson concluded that the deviation from a 1:1 ratio in his sample was probably the result of differences in feeding behavior between the sexes and/or selectivity of trapping methods for certain sex and age groups. The high proportion of males at Duperow suggests differential mortality between the sexes or a bias toward collecting males.

Records of grouse collected at Duperow indicate that they segregate into flocks during the winter according to sex and age. Caldwell (1976) captured 13 birds from a flock of 21 grouse and 8 from a flock of 18 in winter. All captured birds were females which suggests separation into sex specific flocks. There was no age segregation since both flocks contained adults and juveniles. Hamerstrom and Hamerstrom (1951) caught 21 males but no females out of one

flock of sharp-tailed grouse. These observations strongly suggest that in winter grouse segregate into flocks with members of their own sex.

The high proportion of males at Duperow may be explained by differences in behavior of males and females. Even during winter the territorial males spend some time nearly every morning on the dancing ground and do not begin to feed until after the display period. Females do not attend dancing grounds during winter and begin to feed shortly after they emerge from snow roosts. After feeding, they burrow into the snow again. Therefore, males are exposed to collecting for a longer period of time. Comparisons of the mean time of collection of males and females supports this view (Table 2). Males were collected later in the day, on average, than females. However, the differences were not statistically significant.

From December to February the average flock size from which grouse were collected was 10.04 birds (47 flocks) for males and 4.82 birds (28 flocks) for females. This may be another factor biasing the sex ratio in favor of males, since large flocks of grouse are easiest to locate and collect from.

The age ratio of grouse collected at Duperow was 49 juveniles/100 adults. Age ratios of hunter killed sharp-tailed grouse in Saskatchewan between 1957-1977 ranged from 82 to 491 juveniles/100 adults and averaged 158 juveniles/100 adults (unpublished data, Saskatchewan Tourism and

Renewable Resources). The age ratio from the Duperow sample is much below these figures. Even if only the sample collected from September through November (during the regular hunting season) is used, the age ratio is only 92 juveniles/100 adults. Whether this is representative of production over the study area or whether it has been biased because of differences in behavior of the two age groups affecting susceptibility to collection could not be determined.

Habitat Use

Moyles (1977) reported changes in seasonal and daily habitat use by sharp-tailed grouse on the Camp Wainwright Military Reserve, Alberta. He found that they preferred grassland and grassland-low shrub transition habitat types throughout the year. Trees were used heavily in winter and spring when grouse were observed feeding on aspen buds. At Duperow the habitat type which received the highest use by grouse was cultivated fields. Grassland received high use only in spring. However, a direct comparison of habitat use is not legitimate because of differences in land use on the two areas. At Wainwright the study area is made up entirely of native grassland, shrubs and trees which receives only limited grazing. There is no cultivated land. In contrast, at Duperow although the native habitat is similar to that at Wainwright nearly all of the grassland is grazed intensively and much of the land on the periphery of the study area is cultivated. At Duperow use of tall shrub habitat was more important and use of grassland was less important than at Wainwright. I believe that the reason for the difference is that grazing has reduced the value of the grassland for cover at Duperow and as a result the grouse make more extensive use of tall shrub habitat.

Effects of Snow on Grouse Behavior

In both winters snow depths were adequate for roosting (19 cm) (Figure 7) in low and tall shrub cover by the third week of December. Snow quality is just as important as quantity. Low shrub, tall shrub and tree habitats all had snow depths adequate for roosting but by the third week in December 1978 the quality of the snow in the low shrub had deteriorated because of the formation of a wind packed surface crust. A further deterioration occurred in snow quality in the low and tall shrub habitats as the winter progressed.

The major habitat used for snow roosting was tall shrubs. The tall shrub habitat in Figure 8 was on a more exposed site than stands normally used by grouse. The exposure to wind action created a surface crust which made the site unsuitable for snow roosting. Snow quality at sites used by grouse was similar to that recorded on the willow habitat type.

There were no significant differences in the average snow depths at the sites of roosts (Figure 9). Mean snow depth was also fairly constant among habitat types (Figure 7). Apparently compaction, sublimation and drifting counterbalanced the additional snowfall after mid-December. Snow roosts were significantly deeper in December than in February or March (Figure 9) and similarly the mean thickness of the roof was greater in December (6.3 cm) than in February (5.1 cm) or March (4.6 cm). Differences in total roost

depth appear to be due mainly to roof thickness. Because the mean minimum temperatures in December (-24° C) and January (-26° C) 1977-78 were colder than in February (-21° C) and March (-10° C), grouse may have responded to temperatures by digging shallower roosts. Also, the changing nature of the snow through the season may have influenced the depth at which grouse roosted. In February and March the snow surface begins to melt and becomes compacted. Snow below the top few centimeters becomes crystalized. Although these crystals do not obstruct tunneling most of them fall to the floor of the tunnel and the only snow remaining in the roof is more compact. This in turn may be covered by new snow.

Gullion (1970) reported that ruffed grouse under 15-20 cm of snow are in an environment that is about -7° C (20° F) even when the air temperature may be 28 to 33° C colder at the surface. The roofs of sharp-tailed grouse roosts are less than 15 cm thick. Therefore roosts may be slightly cooler than those of ruffed grouse but the benefits would be similar. They protect birds from the wind, the temperature is significantly warmer and it does not fluctuate as greatly as ambient temperature.

Since mean temperatures on the study area during December, January and February are considerably below -7° C there are substantial energy savings to grouse which are able to roost in snow.

Svoboda and Gullion (1972) stated that an evening meal

might sustain a ruffed grouse 14 to 18 hours or longer. Formozov (1973) reported that hazel hens do not spend more than two to three hours feeding and remain in snow roosts the remainder of the day. Daily activity patterns of sharp-tailed grouse at Duperow indicate that the peaks of feeding in winter occur between dawn and 1100 hours and between 1401 hours and dark (Figure 12). These observations suggest grouse feed twice a day. However, a decrease in the number of grouse observed as the day progresses (17.1 grouse/hr from dawn to 1100 hrs, 2.72 grouse/hr from 1401 to dark), suggests that after the morning feeding period most grouse tunnel into snow roosts and do not emerge again, unless disturbed, until the following morning.

Territorial males attend the dancing grounds almost daily throughout the winter but display periods are brief and generally restricted to the short time after they arrive on their territories. By having shallow roosts on the dancing ground, they are able to defend their territory if the need should arise. At the same time, they save energy by getting out of the wind since most grounds are quite exposed. It would be interesting to compare the territories of dominant males in April to those territories which have conditions suitable for shallow roosts in winter and to compare the condition of males which had access to shallow roosts to those which did not.

Grouse were observed on gravel roads far more frequently in winter (26% of all birds recorded) than in autumn

(5%) or spring (7%). Presumably these birds were on the road for the purpose of collecting grit after snow covered natural sources. Waste grains were also present at some locations. Since grouse are able to live in areas without gravel roads it could be argued that they do not require grit found on roads and that this source is simply a convenience. The suggestion has been made, Swanson (1940) that hard seeds such as rose may be a substitute for grit. I believe that even though rose seeds may substitute for grit they are not as efficient for grinding hard seeds. When natural sources of grit are covered by snow it is advantageous for grouse to pick grit on roads. They conserve energy by spending less time at this activity than if they were searching for natural sources and their gut can make more efficient use of food because the gizzard is working more efficiently.

Food Habits

Sharp-tailed grouse chicks feed primarily on animal foods for the first few weeks of their lives. In fall they switch to a vegetarian diet. Adults are primarily vegetarian in all seasons (Kobriger 1965), (Pepper 1972), (Sisson 1976). Foods used in the fall include seeds and berries of wild fruits (rose, juniper, snowberry), green leaves (dandelion, clover *(Trifolium* spp.)) and domestic grains (Marshall and Jensen 1937, Aldous 1943, Harris 1967, Kobriger 1965, Pepper

1972, Sisson 1976). Buds from woody species (chokecherry, saskatoon, maple *(Acer grandidentatum)*), berries and grain are the major foods used in winter (Schmidt 1936, Marshall and Jensen 1937, Aldous 1943, Rogers 1969, Sisson 1976).

Marshall and Jensen (1937) believe that in winter food habits are greatly influenced by availability of food which was directly affected by snow depth. However, food habits may also be influenced by selection for plant species with a high nutritional value. Gardarsson and Moss (1970) concluded that Icelandic ptarmigan *(Lagopus mutus)* are selective feeders and most of the preferences can be explained by the fact that the preferred foods are of greater nutritive value than the less favored items. Doerr et al. (1974) found that ruffed grouse selected aspen buds which had higher protein and potassium content than random samples of buds collected in trees in which they were observed feeding. Sharp-tailed grouse probably also have this ability to select food items with the highest nutritional value.

At Duperow grouse sometimes flew 0.8 to 1.6 km from a dancing ground to feed on grain (crude protein 13-15%) when other foods such as aspen buds (crude protein 11%), chokecherry buds (crude protein 14%) and berries (crude protein 5-7%) were much closer. The shift from a diet consisting primarily of grains and berries in February to one of aspen catkins (crude protein 15%) and dandelions (crude protein 17-23%) in April and May when grains and berries were still available also indicates the grouse were

selecting species for their nutritional value. The results of tracking grouse which were feeding showed that they were selecting some species and not just randomly feeding on what was available.

Although aspen buds and chokecherry buds contain more protein than any of the berries they made up a relatively small portion of the diet of grouse in winter. In other studies (Marshall and Jensen 1937, Aldous 1948) buds were a major component of foods consumed in winter. Grains and buds have a similar protein content but may differ in other nutrients which result in grouse selecting grains. It is also possible that they prefer to feed on the ground as long as grains are available. At Duperow grouse were able to feed in cultivated fields during both winters of the study.

Seasonal Changes in Body Components and Fat Depots

The winter of 1976-1977 was slightly warmer and had less snowfall than the following winter (Figure 6). Grouse may not have required as much maintenance energy because of the warmer temperature the first winter but this was not reflected by differences in body weights as there were no significant differences between years (Table 8). If a relationship existed between energy requirements and temperature it may have been obscured by other variables.

Caldwell (1976) found no significant differences in total fat content of sharp-tailed grouse during four periods of the year. The four periods he compared were November 1 through April 1, April 1 through June 15, June 15 to September 15 and September 16 through October 31. My collections were each month from September to mid-May and, therefore, cannot be compared directly to his results. However, there were some significant differences between body weights, weights of breast and leg muscles and weight of fat depots of males when monthly means were compared. I believe that the fluctuations which I observed in the fat cycle in winter were masked in Caldwell's study because of the broader time periods he worked with. Fat content averaged 1.3% of wet weight in Caldwell's sample. He concluded that if grouse require stored energy during breeding, they would have to burn protein because the fat reserves on a 900 g grouse would amount to only 11.7 g or 105.3 Kcal (only 1.4 times the basal metabolic rate). Fat extractions were not conducted on the grouse collected at Duperow but three fat depots were weighed. These depots are only a fraction of the total fat in the carcass and did not include fat from the mesenteries of the gut, depots on the legs or the subcutaneous fat from the skin. The depot fat varied from 0.4% to 3.3% of the monthly mean wet weight. Mean weights of the fat depots were 20 and 17 gm respectively in March and April. Total fat reserves would exceed these figures and, therefore, the energy reserves available to

these grouse could be double the amounts reported by Caldwell.

Fat depots on the neck (Figure 4) and in the abdominal cavity of grouse (Figure 5) are important energy reserves and may also act as insulation to slow down heat loss from these areas. Evans and Moen (1975) appear to have overlooked the insulating value of the interclavicular fat depot when calculating rates of heat loss from the neck of sharp-tailed grouse.

Although fluctuations in body weight do occur, the mean weight in May near the end of dancing ground activity is still greater than the mean weight in February. Although weights of pectoral muscles decrease, the weights of leg muscles increase. Similar changes in pectoral and leg muscle weights have been documented in mallard ducks *(Anas platyrhynchos)* (Young 1977) and Canada geese *(Branta canadensis)* (Hanson 1962). In these species the decline in pectoral muscle weight may be related to inactivity of these muscles during wing molt and the increase in leg muscle weights may be a result of the increased use of these muscles for swimming while the birds are flightless. Male sharp-tailed grouse use their leg muscles more during the breeding season than other periods of the year. Whether the decrease in pectoral muscles is a result of the males flying less during this period has not been documented.

Fluctuations in total body weight of male ruffed grouse between October and May reported by Thomas et al. (1975)

closely parallel the fluctuations of weights of male sharp-tailed grouse described here except that male ruffed grouse lose weight in April through May while sharp-tailed grouse gain weight between March and April and lose weight in May. Changes in weight between October and April were not significant in ruffed grouse but those in sharp-tailed grouse were statistically significant. Changes in the body weight of male spruce grouse (Pendergast and Boag 1973) do not follow the same pattern as ruffed grouse and sharp-tailed grouse. Body weight in spruce grouse increases from August to October, is fairly stable from October to December, declines from December to February and drops again between March and May.

Between January and May pectoral muscles of male ruffed grouse varied from 34% to 37% of the total body weight (Thomas et al. 1975). Pectoral muscle weights decreased from January (n=2) to February but no differences existed from February to May. Pectoral muscles of sharp-tailed grouse varied from 30% to 31% of total body weight between September and March and then dropped to 28% in April and May. Differences between these species with regard to the proportion that the pectoral muscles contribute to body weight may reflect differences in their courtship or territorial defence displays. Ruffed grouse may have evolved proportionately larger pectoral muscles than sharptails because they use them for drumming. In sharp-tailed grouse the emphasis of the display is on the use of legs not wings.

During the breeding season the leg muscles increase in weight and the breast muscles decrease.

Weight of the pectoral muscles of spruce grouse (Pendergast and Boag 1973) do not appear to fluctuate as greatly as those of ruffed grouse or sharp-tailed grouse. They are also a smaller proportion of the total body weight, approximately 16%.

Pendergast and Boag (1973) did not consider depot fat to be a significant factor in weight changes of spruce grouse. Thomas et al. (1975) did not observe any marked seasonal increases in lipids in ruffed grouse and concluded that lipids are not of great metabolic importance to ruffed grouse during winter. West and Meng (1968) found that the lipid index for willow ptarmigan was higher in the autumn and spring than in winter. The high index corresponded to the times of migration for this species. However the changes represent a difference of only 6.5 g of fat which is only about one-third of the average daily energy requirements of willow ptarmigan.

Sharp-tailed grouse appear to store more fat than other members of the Tetraonidae. Significant changes occur through the winter. The mean weight of fat depots of males collected in December was 30 g. Some individuals had stores up to 50 g.

The decrease in weights of grouse from November and December to February indicates that the birds are unable to

obtain enough energy from foods to equal their metabolic demands. During this time they are in a negative energy balance and use part of their fat reserves to satisfy energy demands. Some protein may be metabolized because pectoral muscles and leg muscles also decrease during this time. However, fat depot and pectoral muscle weights in February are not significantly lower than in September. These observations indicate that the ability of grouse to build up energy reserves in autumn and early winter was an adaptation to compensate for periods of negative energy balance under the weather and snow conditions observed at Duperow.

Seasonal Changes in Lengths of Small Intestine and Caeca

Lewin (1963) found that seasonal changes in the lengths of the small intestine and caeca of California quail *(Lophortyx californicus brunnescens)* were associated with changes in their diet. Lengths increased in winter when they were feeding on green plant material which is more bulky and may be less nutritious than seeds on which they feed in summer. Pendergast and Boag (1973) found that the lengths of the intestines and caeca and the weight of the gizzard of spruce grouse increased in winter, apparently due to a change in diet at that time. Japanese quail *(Coturnix coturnix japonica)* fed on a high fiber diet, ate more and had greater gut lengths than birds on a low fibre diet (Savory and Gentle 1976). Apparently the longer gut allows the birds to process the greater bulk of food which must be digested in order to satisfy their nutritional requirements. Fenna and Boag (1974) reported that Japanese quail held under cold conditions (2° C) consumed more feed and had significantly longer small intestines and caeca than quail held at 23° C. These differences were related to differences in the rates of food consumption (higher consumption at colder temperatures) and not to food quality.

Gut lengths in sharp-tailed grouse are longer in winter than in spring or autumn. Their diet in winter is mostly seeds and berries. Green plant material is an important part of the diet at other times of the year.

This is the opposite of the diet of California quail. The longer gut length in winter in both species is related to the quantity of food they require to satisfy their metabolic requirements. Although sharp-tailed grouse feed on high protein grains in the winter the sub zero temperatures dictate that they must consume greater quantities than in summer if they are to satisfy their metabolic requirements. If the gut could not adapt to process the large amounts of food the grouse would be in an even greater negative energy balance than has been documented in this study.

SUMMARY

The basic needs of sharp-tailed grouse in winter are food, water and shelter from the elements and from predators. Factors which prevent grouse from fulfilling these needs may have a direct effect on their survival. Air temperature and wind speed are two factors which have a considerable influence on energy requirements of these birds (Evans and Moen 1975). Gullion (1970) believes that when temperatures drop below -7° C (20° F) they are below the thermoneutral range of ruffed grouse which must then increase their metabolic rate to maintain body temperature. Since sharp-tailed grouse are larger they may be able to withstand slightly cooler temperatures before they have to increase their metabolic rate. In the present study mean temperatures dropped below -7° C only in the months of December, January and February. Therefore, these are the months when energy demands should be greatest, unless the grouse can seek shelter where temperatures were warmer. They do this by roosting under the snow where temperatures are near their thermoneutral range. This behavior also affords protection from wind and further reduces heat loss from windchill. Snow roosting also affords concealment from predators for most of the day and may reduce predation.

Two methods of lessening the high energy demands of grouse during periods when they are above the snow surface might be selection of high protein - high energy foods and/or

the storing of fat in the fall in preparation for future demands. Examination of total body weight of male sharp-tailed grouse through the winter (Figures 15 and 17) indicates that they gain weight from September to December. During this same time fat reserves increase by a factor of 6. Temperatures are above the thermoneutral range from September through November and the diet at that time is approximately 50% grain which is high in protein compared to many native food sources. It appears that the moderate temperatures and a high protein diet at this time of year are responsible for the observed gains in both body weight and fat reserves.

Body weight and fat reserves decline from December through February. This corresponds to the time when grouse are able to conserve energy by snow-roosting thus partially compensating for metabolic demands related to temperatures below their thermoneutral range. At the same time, a change in food habits occurs in which grains make up a smaller portion of the diet, especially in January. Apparently energy demands cannot be met during this period and as a result they are in a negative energy balance.

When temperatures moderate in March the diet is sufficient to meet the lessening metabolic requirements. This results in a positive energy balance and the birds increase in weight. In April and May green leaves and aspen catkins replace grain as the high protein component in the diet. Body weight increases in April in spite of

the large energy expenditure of males on territorial display and defense followed by a decline in body weight and fat reserves from April to May. Body weights of female grouse increase from February to May. This increase is related to changes in reproductive condition.

Longer gut lengths and a larger gizzard in winter appear to be an adaptation of grouse for processing large quantities of food in an attempt to meet high metabolic demands.

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Appendix 1: Form used for recording necropsy data of sharp-tailed grouse.

Date _____ Time _____ Collection No. _____

Location _____ Habitat _____

Number Observed _____ Activity _____

Temp. ___°C Wind ____ Clouds ____/10

Coll. Method _____ Sex ____ Age ____

Wing Length _____

Necropsy Date _____

Total weight _____ gm

Crop contents _____

Subtotal _____

Gizzard contents _____

Wet weight _____ gm

Leg muscles _____ gm

Width tail _____ cm

Liver _____ gm

Heart _____ gm

Gizzard and Provent _____ gm

Breast Muscles _____ gm

Fat depots _____ wt

Interclavicular _____ gm

Rear of sternum _____

Abdominal _____

TOTAL _____ gm

MALE testes ____ mm X ____ mm

FEMALE oviduct width ____ mm

Diam. largest foll. ____ mm

BURSA ____ mm X ____ mm

GUT MEASUREMENTS

Length of cacecae ____ cm ____ cm

Length of large int. ____ cm

Length of small int. ____ cm

COMMENTS:

Appendix 2: Foods of sharp-tailed grouse as determined from crop and gizzard contents.

	PERCENT OCCURRENCE						
ANIMAL MATTER	Sept. Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April May
Grasshoppers	8	5	-	-	-	-	4
Beetles	20	-	-	-	-	17	33
Spiders	4	-	-	-	-	-	4
Ants	-	-	-	-	-	-	11
True Bugs	4	-	-	-	-	6	-
Insect Larvae	-	-	-	-	-	6	7
PLANT MATERIAL							
Seeds							
Wheat	28	19	33	33	36	22	4
Oats	20	19	48	30	28	39	4
Rye	-	10	29	11	4	17	-
Barley	16	10	5	-	16	11	7
Buckwheat	20	52	57	11	28	22	4
Unidentified	4	19	-	-	8	-	-
BERRIES							
Silverberry	36	19	33	93	56	28	15
Snowberry	56	62	90	96	84	72	48
Rose	44	52	90	96	92	17	30
Juniper	56	38	10	7	20	72	63
Bearberry	36	10	-	-	-	22	19
Choke cherry	-	-	19	7	4	-	-
Saskatoon	-	-	-	4	-	-	-
Gooseberry	-	-	-	7	-	-	-

PERCENT OCCURRENCE

BUDS	Sept. Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April May
Choke cherry	20	19	33	67	40	28	7
Saskatoon	8	5	19	22	20	6	4
Aspen	24	14	19	52	20	-	11
Pin Cherry	-	-	10	41	16	6	-
Buffaloberry	-	-	-	4	-	-	7
Willow	-	24	-	7	16	-	4
Silverberry	-	19	14	11	-	17	7
River Birch	-	10	-	-	-	-	-
Balsam Poplar	-	-	-	-	4	-	-
Unidentified	-	14	5	15	4	11	7
CATKINS							
Aspen	-	-	-	-	-	-	41
River Birch	-	10	-	-	-	-	-
Willow	-	-	-	-	-	-	4
FLOWERS AND LEAVES							
Dandelion	20	10	-	-	12	-	30
Perennial Sowthistle	8	5	-	-	-	6	4
Prairie Crocus	-	-	-	-	-	-	19
Unidentified Compositae	-	-	14	-	-	-	4
Unidentified Leaves	100	90	62	37	52	67	89
Sample Size	25	21	21	27	25	18	27